CROSS TALK

▶**DEFINITION** . . . At the National Electronics Conference, Dr. E. U. Condon, Director of the Bureau of Standards, proposed a new definition of electronics: "the science, art and industry concerned with electrical phenomena involving charged atomic particles outside of solid and liquid bodies." In so doing Dr. Condon welcomes to the confraternity of particles, once limited to electrons and ions, several brothers and sisters, the positron, proton, alpha particle, deuteron and meson. Only the chargeless neutron and neutrino are excluded. There was a time when a respectable science could be built on just one particle, but that time has passed. There seems to be no fundamental conflict between Dr. Condon's proposition and the hallowed definition of the AIEE, "That branch of science and technology which relates to the conduction of electricity through gases and in vacuo." But the family of conductors has grown with the years.

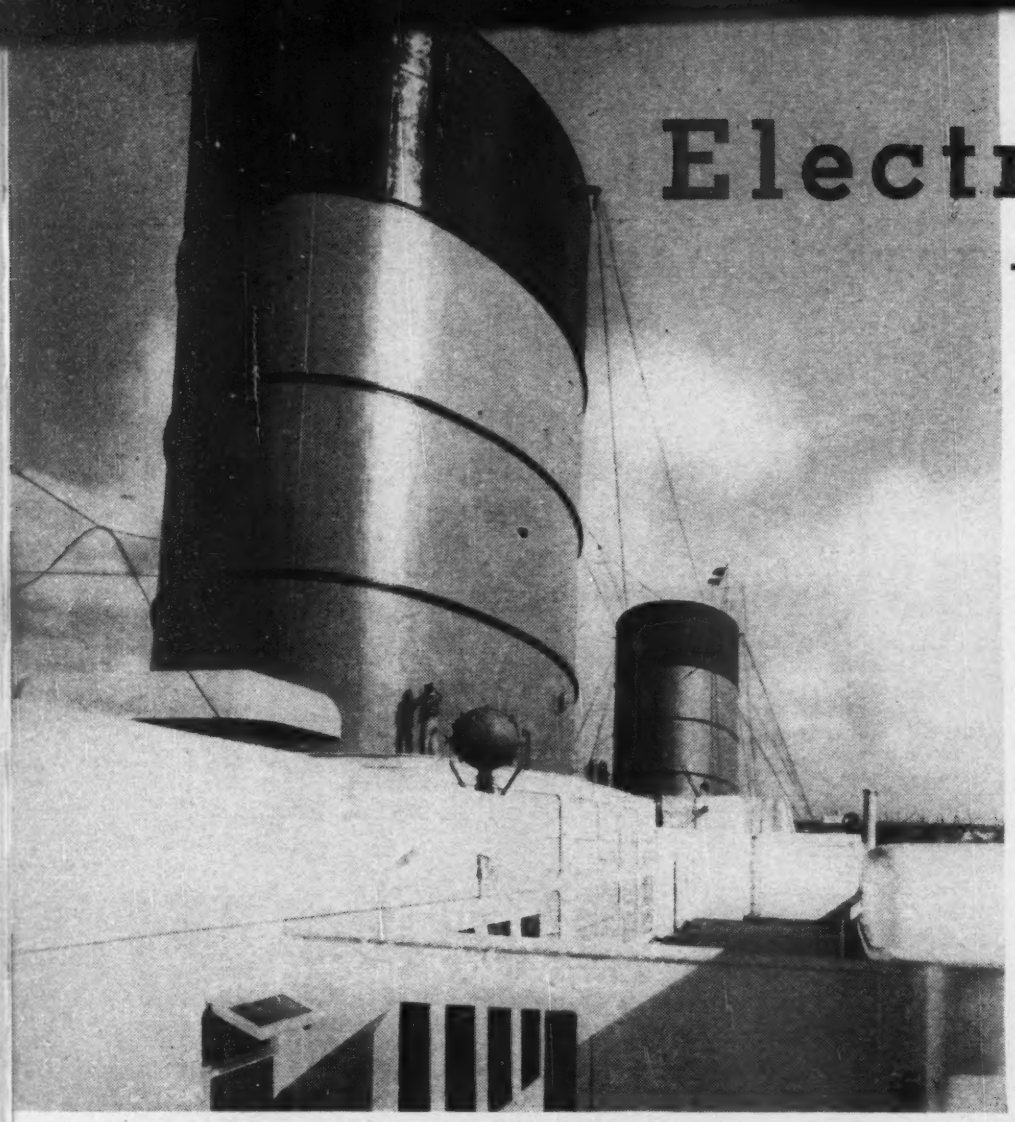
Speaking of definitions, we find the radio engineer defined by the Canadian Council of the I.R.E. as one who combines in himself some proportion of the electrical engineer, the business man and the physicist. Like many a true word, this definition is likely to be resented by all parties mentioned!

▶**SKYWAVES** . . . Radio and astronomy seem to be crossing paths regularly these days. First were the Signal Corps radar echoes from the moon. Then M. W. Baldwin of Bell Labs reported the existence of mysterious echoes from regions in the atmosphere about two kilometers high. These objects or regions are invisible to optical telescopes, but are regularly observed on 10-cm and 3-cm radars, moving about 30 miles an hour, sometimes with the wind, sometimes against it. Source unknown. More recently, the meteor showers in October were thoroughly watched by radio and radar. Individual meteors were tracked by radar at White Sands, New Mexico, using equipment set up to track the V-2 rockets. J. A. Pierce and his group at Harvard recorded meteor whistles (Doppler beats caused by reflection from the meteor of a steady c-w carrier) during the showers. Pierce also successfully recorded the "artificial" E-layer induced by a meteor shower, and has traced the ionization from the aurora borealis in a cathode-ray picture which bears a striking resemblance to the visible aurora. After years of effort aimed ultimately at destruction, these new fields of activity have all the freshness of a spring breeze.

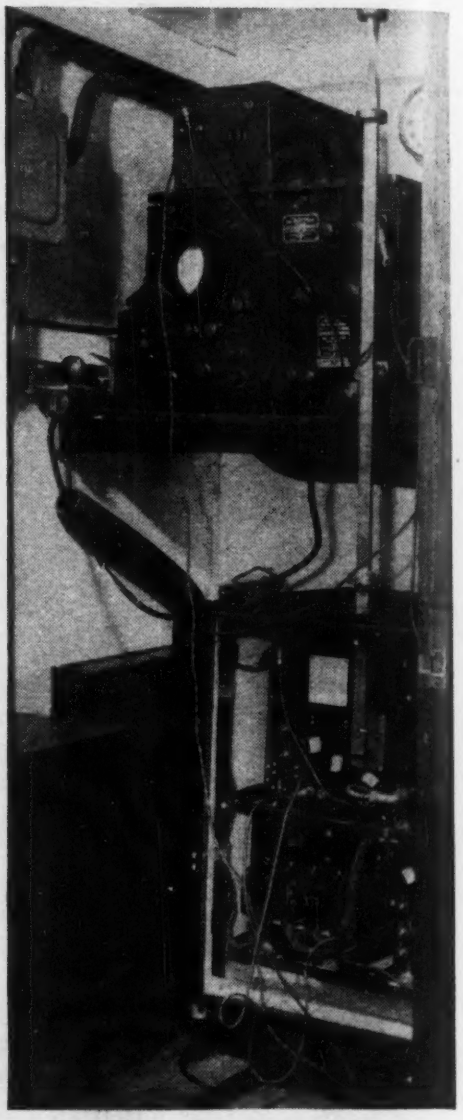
▶**BASIC** . . . Viewers with alarm of the heavy financial support by Army, Navy and Air Force in the research programs of the colleges may take heart from the fact (recently confirmed by two large eastern institutions) that the military are taking, and liking, basic research under their collegiate contracts. Many were the fears that the immediate problems of military science would displace the traditional untrammeled atmosphere of scientific endeavor. Nor were the fears entirely unfounded. Many "here's the breadboard, please make it work" problems have been taken to the colleges from NRL, Watson Lab, Belmar, and Wright Field. But all such have been turned down as interfering with more vital basic research. Moreover, the contracts are so written that the turn-downs stick.

How long government money will continue to be available for this purpose is anyone's guess. But so long as the people and the Congress remain convinced that research is the beginning of defense, and so long as the contract admininstrators insist that the research be basic, not superficial, much good will come from it, not only as a protection against war but for positive use in peace.

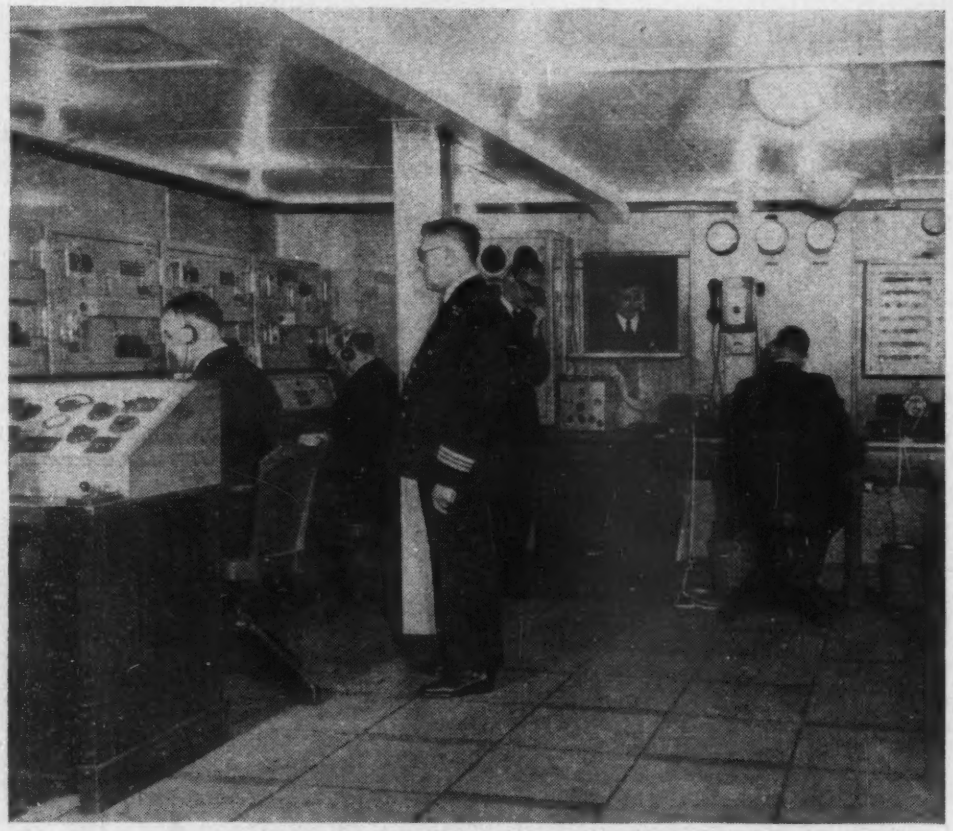
Electronics on



Radio antennas on the Queen Elizabeth, held at minimum to preserve graceful lines of ship, are supported largely by these two huge decorative funnels



Loran equipment on shelf, with radar transmitter below. Waveguide goes to spinner on roof of bridge



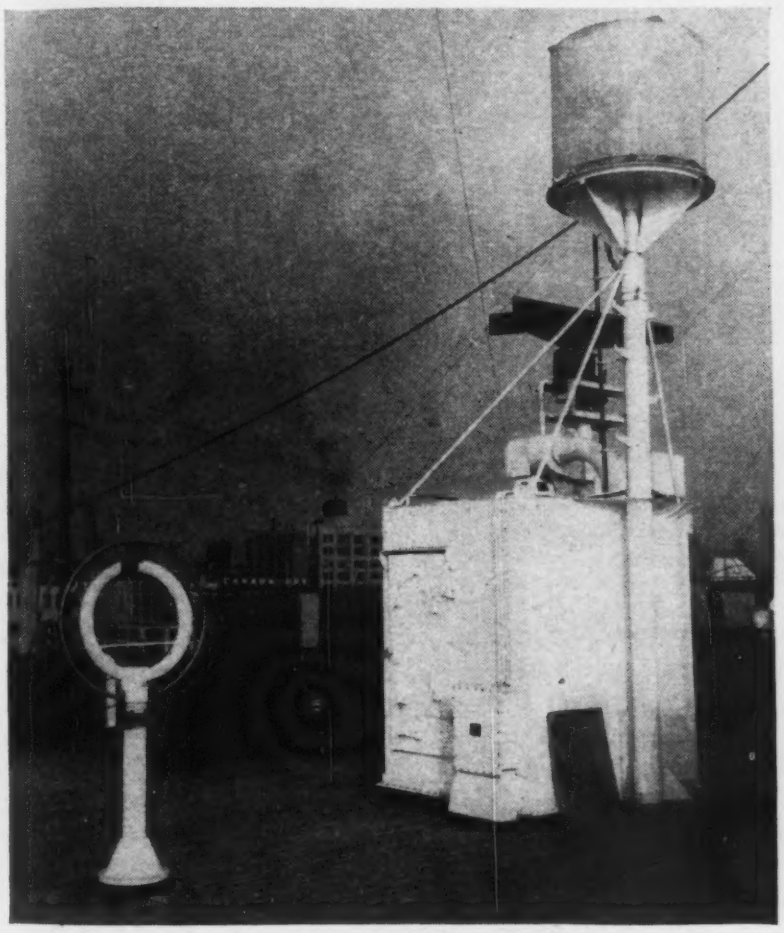
Main radio control room of Queen Elizabeth, showing operating positions and master control desk. The entire marine radio installation was made by International Marine Radio Co. Limited, an I. T. & T. affiliate. Speech secrecy racks fill another wall

PICTURES taken after the maiden commercial run of the 83,673-ton superliner Queen Elizabeth reveal that the military electronic equipment which helped her to dodge enemy aircraft and submarines during the war is now contributing to the safety and speed of peacetime trips as a luxury liner. On the bridge 90 feet above the water, British and American equipment operates side by side when bad visibility renders visual observation impossible, permitting full speed even in iceberg zones or in heavily travelled shipping lanes.

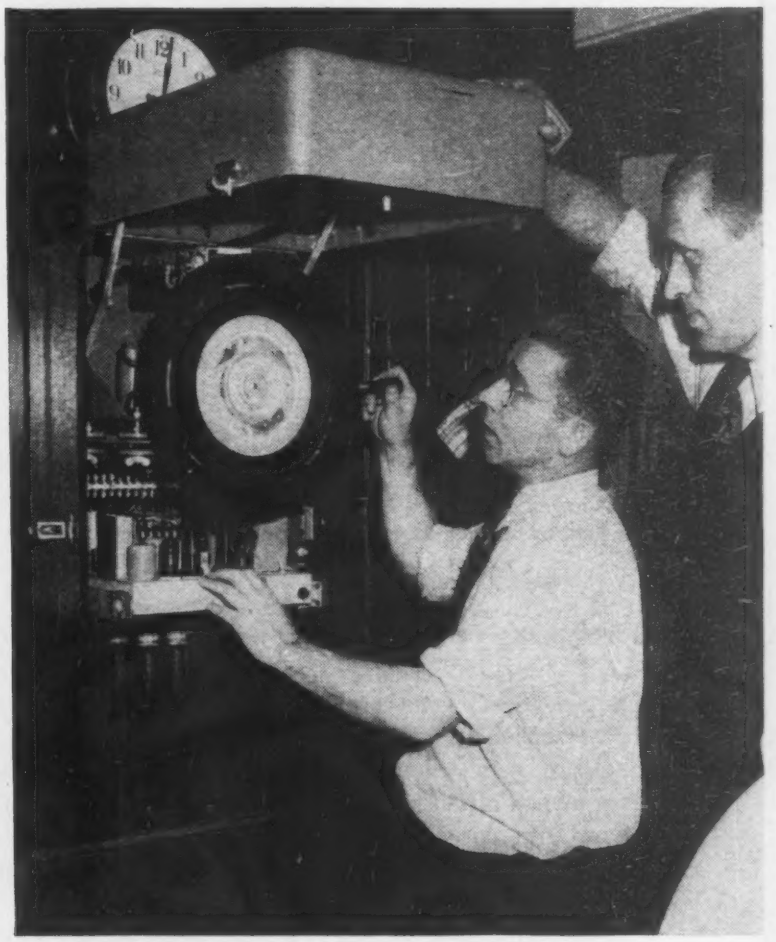
Loran equipment for navigation

World's Largest Liner

Radar, loran, depth sounding, and radio installations of the Queen Elizabeth played major roles in successful evasion of submarine packs and enemy aircraft during the war, now contribute to safety of all-weather navigation on trans-Atlantic passenger runs



Radar and radio d-f antennas on roof of bridge, with radio direction-finding loop at left. Another d-f loop is directly above the main radio room



Service technicians E. K. Fricke (left) and F. Eklund of Bludworth Marine making routine maintenance adjustments of echo depth-sounding indicator in wheelhouse

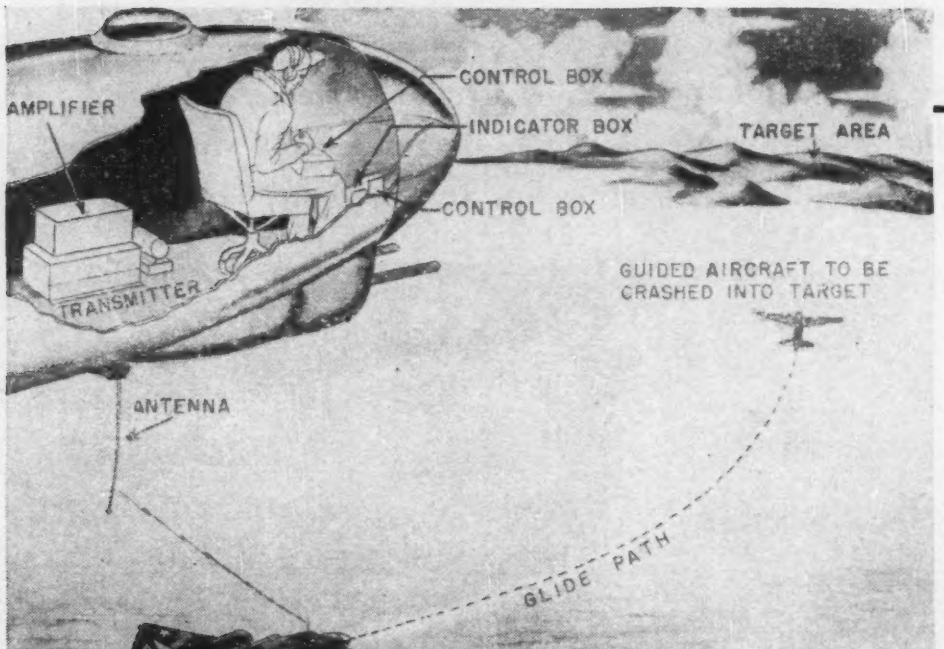
is located in a small room directly behind the wheelhouse. This is standard U. S. military design, model DAS-2 made for the U. S. Navy by General Electric Co. It employs marker scales on the scope screen for determination of loran line numbers, as described in ELECTRONICS, Dec. 1945, p. 110. Supplementing loran for precise position determination at short ranges is British Gee equipment, also a pulse-timing system.

Radar equipment is all British. Transmitters are in the loran room directly under the radar spinners, and the indicators are in a midget darkroom located in a corner of the wheelhouse. Ranges of the two Cossor search radars are 10 and 50 miles respectively. Aircraft search radar used during the war was not evident when the ship docked at pier 90, New York City on her maiden passenger run.

In shoal waters echo depth-sounding equipment is turned on. This provides, on an indicator alongside the helmsman, an exact reading of depth in large neon-illuminated numerals, and simultaneously produces a continuous and permanent record of ocean-bottom profile in the chart room as a supplementary guide for navigators.

The radio installation consists of four remotely located main transmitters, a main radio room with four operating positions, message secrecy units (speech scramblers) to insure privacy of personal radiotelephone calls to shore, a complete emergency radio station that is independent of the ship's power supply, and a low-power radio set in the wheelhouse which enables the Captain, navigating officers, and pilot to converse directly with personnel on tugs or the quayside when docking. Two of the 26 motor lifeboats carry transmitters.

RADIO CONTROL



Tactical use of a Weary Willy, as sketched by William Bass to show how operator in Mother aircraft at upper left controls direction and flight functions of explosive-filled bomber on last flight, using ARW-18 remote control equipment

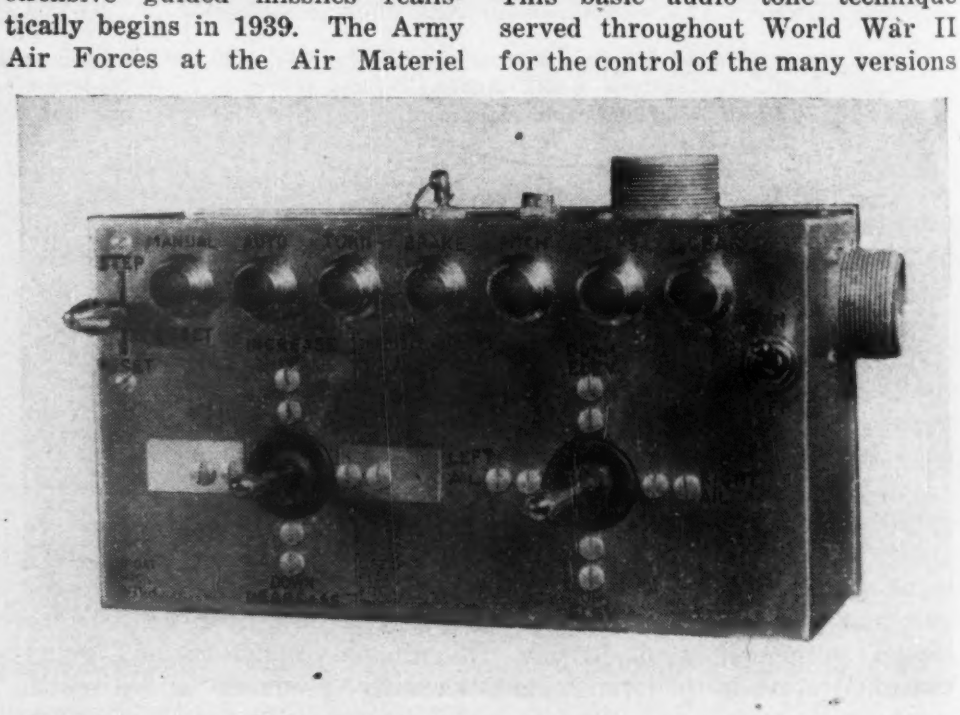
DURING THE EARLY STAGES of World War II, while the Army Air Forces were undertaking the destruction of Germany with the help of newly developed techniques for high-altitude radar precision bombing, American scientists were perfecting an even more practical and accurate bombing method. Their scientific collaboration resulted in a series of remotely-controlled experimental missiles. One of these, the Roc, could hit a circle 100 feet in diameter from an altitude of 15,000 feet, without ground visibility. Another, the GB-4 glide bomb, was less accurate but was capable of being released and guided to the target by an aircraft some 20 miles from the target and outside the flak zone. Still another, the Razon VB-3 free-falling bomb, when released from altitudes of 15,000 feet, would under conditions of good visibility strike within 20 feet of the target area.

The conception of pilotless aircraft dates back to experiments performed in 1918, when a young officer, Capt. Henry H. Arnold, collaborated with a young scientist, Charles F. Kettering, and worked out some basic principles. Since then, the captain has become a five-star General, recently retired; the scientist is the vice-president of General Motors Corporation; and the dream of pilotless flight has become a reality.

The story of the development of offensive guided missiles realistically begins in 1939. The Army Air Forces at the Air Materiel Command, Wright Field, Dayton, Ohio, successfully developed, in conjunction with a commercial manufacturer, a radio method for the remote control of pilotless target aircraft, to be used during antiaircraft gunnery practice.

This first system consisted of lightweight aircraft equipped with small radio receiving sets capable of responding to transmitted signals. These signals, in turn, were converted in the receiver to the voltages necessary to control the rudder and elevator of the target plane, thereby directing it in flight. The transmitting equipment, on the ground, sent out to the target a radio-frequency signal coded by impulses to select the flight functions to be performed.

From this beginning, Wright Field laboratory personnel developed and constructed, in the same year, vastly improved radio equipment employing audio tones to select flight functions, with the receiving equipment in the target aircraft using tuned filter circuits. This basic audio tone technique served throughout World War II for the control of the many versions



Control box for ten-channel ARW-18 f-m transmitter used by operator in Mother plane to maneuver a PQ-14 pilotless aircraft

SYSTEMS for Guided Missiles

Descriptions of the more important guided missiles and pilotless aircraft developed by the Army Air Forces during the war, with circuits of representative radio control systems, techniques of tactical usage, control problems, and intimations of future trends

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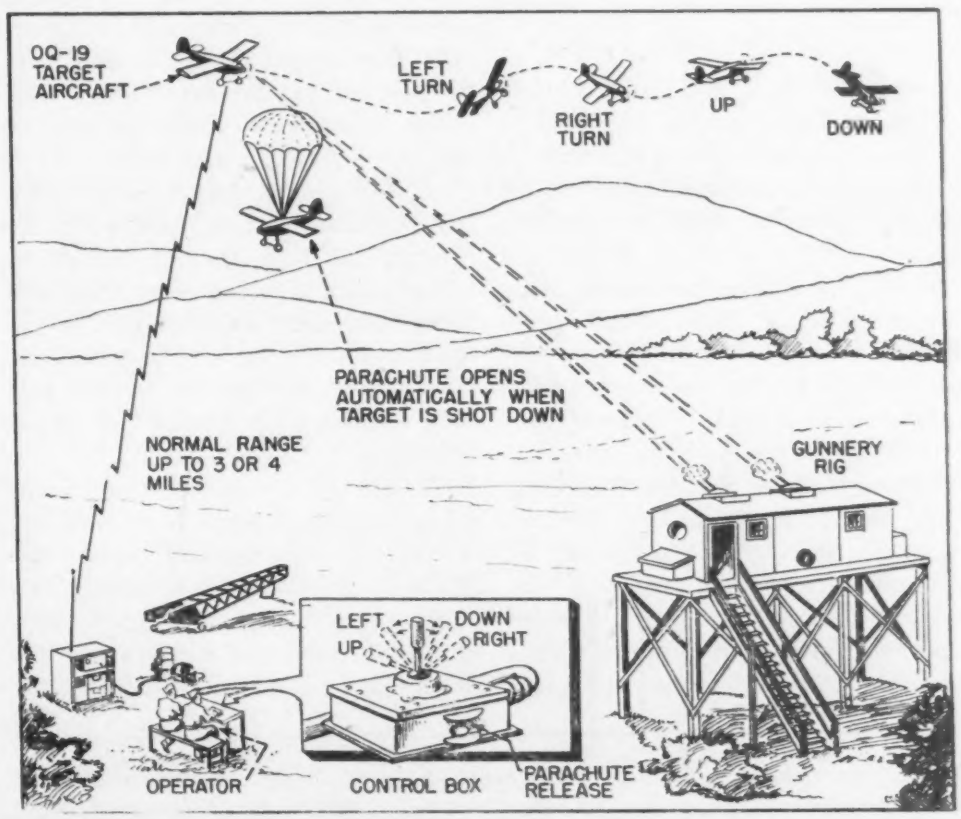
of target aircraft, guided missiles, and free-falling bombs developed by the U. S. Army Air Forces. Other techniques, which came into play in the late stages of the war, invaded such new fields as radar target seekers and radar pulse control techniques. This article will briefly describe the various types of pilotless aircraft, insofar as present security regulations permit.

Target Aircraft

Small pilotless aircraft are controlled remotely by radio, usually launched by catapult and landed by parachute, and used as targets for antiaircraft gunnery crews. Models include the OQ and the almost full-size PQ series of pilotless aircraft and the RC-56, RC-57, RC-64, RC-65, ARW-1 and ARW-18 electronic target-control equipment.

The RC-56 a-m transmitter for remote control of target aircraft may be located as a permanent ground installation, jeep-mounted for portability, or located in a Mother (controlling) flying aircraft. The transmitter may be set to any of four fixed frequencies and may be tone-modulated by any of five audio signals, as called for by the positions of the miniature joy stick and switches that are manipulated by the operator.

The RC-57 superregenerative receiver used in target aircraft contains frequency-selective filter circuits (the decoder) which differentiate between the various tone-modulated signals received, and a relay unit that furnishes control voltages to the servomechanism or other devices operating the rudder and elevator of the aircraft. This receiver could also be installed on trucks, tanks, and watercraft to permit bombing and strafing practice of an evasive target by gunners in aircraft.



Ground installation of model RC-56 a-m transmitter for training gunners firing from gun turrets simulating those used in B-29 and B-32 bombers, with model RC-57 superregenerative receiver in OQ-19 pilotless aircraft serving as evasive target

The PQ-14 target aircraft is a low-wing monoplane powered by a six-cylinder 155-hp Franklin engine. It has a ceiling of 17,000 feet and can operate for 3 hours at a speed of 160 miles per hour. This plane may be maneuvered to simulate strafing of gunnery batteries or high-altitude bombing missions. Its automatic pilot, brakes, retractable landing gear, and flaps are all controllable from the remote control station by means of the ARW-1 10-channel f-m radio receiver and ARW-18 f-m transmitter, which together give 18 controllable functions. Control is accomplished from a modified Beechcraft C-45 Mother plane trailing a safe distance behind the target, with the pilot of the target aircraft sitting in the copilot's seat

and manipulating a miniature joy stick and switches. Indicator lights check his selection of flight functions.

War-weary B-17 bombers no longer fit for combat service, loaded with 20,000 pounds of explosives and crashed into the target by remote control from another plane, were known as Weary Willies. Human pilots were generally used during takeoff, and bailed out while still in friendly territory. Television cameras and transmitters sometimes scanned the instrument board of the Weary Willy or the area in front of it, and relayed the picture back to the Mother plane, which followed at a safe distance of about 20 miles.

Guided Bombs

Azon is a free-falling vertical bomb having controlled surfaces to permit control of its trajectory in azimuth only, for accurate bombing of line targets such as bridges, roads, and railways. The Azon assembly was attached to an ordinary 1,000 or 2,000-pound free-falling bomb. Two fins are controlled by gyros under the influence of a CRW-2 remote control system mounted in the tail assembly. The RC-186 transmitting equipment in the Mother aircraft provided a choice of 47 channels for transmission of the control signal. Two audio control channels gave right and left control for the bomb. In a typical run over the target, the Norden bombsight was used to drop the bomb; seconds later a million-candlepower flare attached to the tail lit automatically, so the bombardier could follow the flight of the bomb visually and make corrections. One serious drawback of Azon is the necessity for making a long run after actually dropping the bomb, during which the plane is a vulnerable target for flak in heavily fortified areas.

Razon is a free-falling bomb controlled in both range and azimuth. It uses a CRW-7 four-channel audio system. A Crab sight attached to the Norden bombsight in the form of a half mirror projects the image of the bomb flare on the target, enabling the Norden sight to show the true height of the bomb as required for range corrections. The same hazardous bombing run as for Azon must be performed.

Spazon is a free-falling bomb which is allowed to spin normally during the first part of its fall to obtain accuracy, and corrections are made by radio as the missile approaches the target. The technique was not altogether successful, and was dropped in favor of other projects.

Glomb is a remotely controlled glide bomb developed to extend the range of the missile from the Mother aircraft and eliminate the dangerous follow-through techniques of Azon and Razon. A wing with a span of 12 feet was attached to a standard bomb, along with a twin boom and a set of tail surfaces that were gyroscopically stabilized and radio controlled. The type GB-4 contained also a complete television transmitter to relay to the bombardier a complete flight picture. Two of these missiles were carried under the wing of a B-17 bomber and released one at a time from an altitude of 15,000 feet and at a distance of 17 miles from the target. The Mother aircraft then made a 180-degree turn while the missile continued on its way to the target. The bombardier, watching his television receiver, directed the bomb to the impact point. The second bomb could then be released and dropped in a similar manner.

Jet bombs constitute a group of guided missiles which for the most part is still classified because of its remote control equipment or because of the aerodynamic characteristics of the bomb. Entirely new techniques are being used for control, the most significant being use of radar stations at the controlling point.

Roc is a glide bomb developed near the end of the war, having unusual aerodynamic control surfaces incorporated in a wing structure that surrounds the belly of the bomb. Controls are operated remotely by two electric motors, in response to signals from the Mother aircraft. The circular fin at the tail of a bomb acts as a drag, slowing the descent sufficiently to

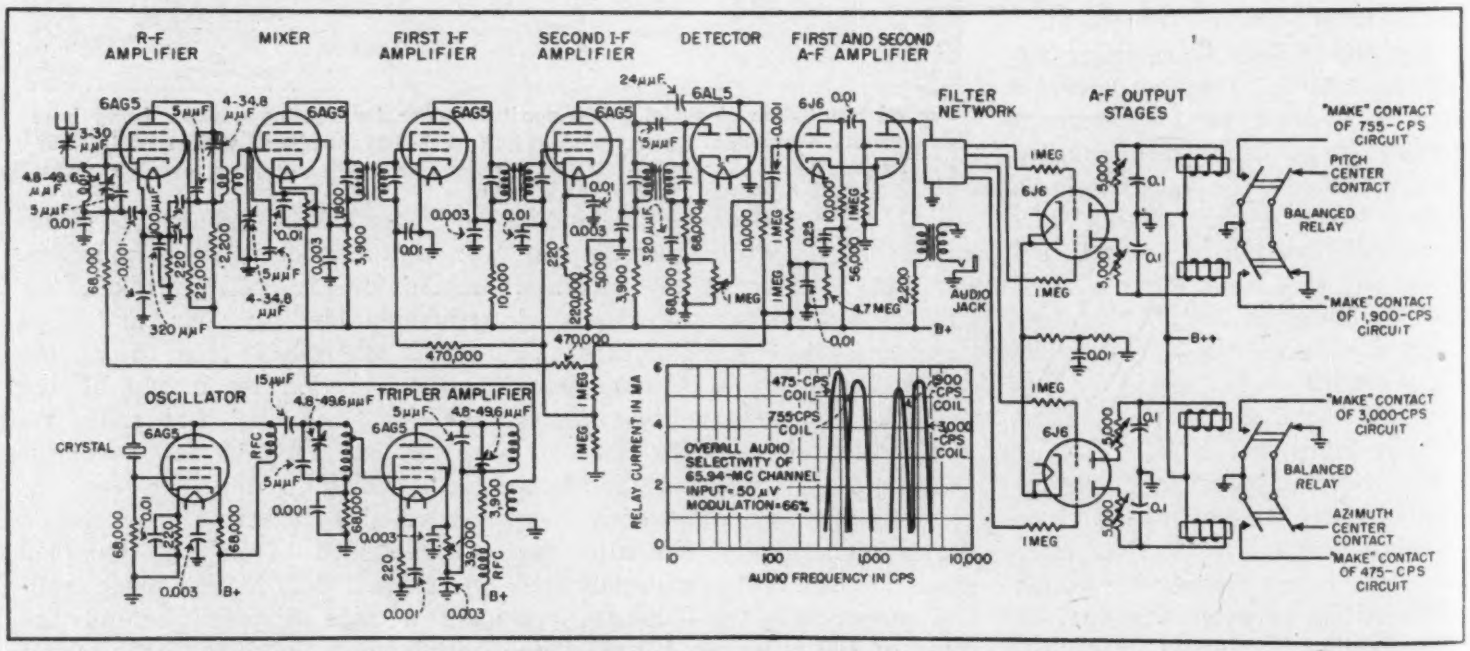


FIG. 1—Circuit of four-channel CRW-7 superheterodyne receiver used for azimuth and elevation control of Razon bombs, with overall selectivity curves for each channel

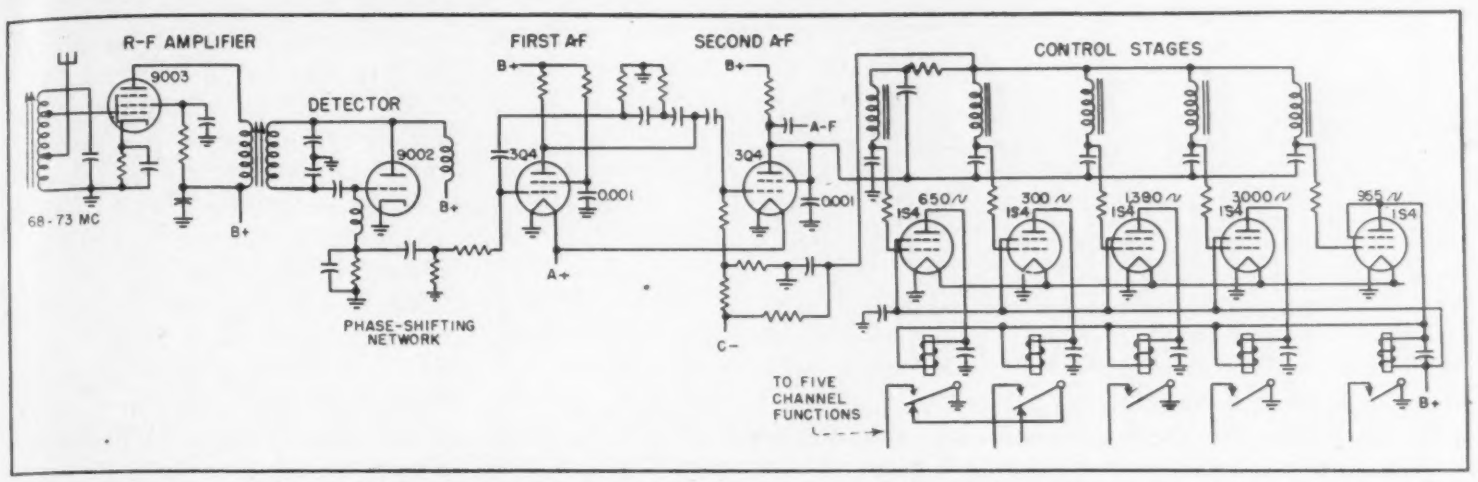


FIG. 2—Circuit of five-channel RC-57 superregenerative receiver used in pilotless aircraft serving as targets for gunnery practice

provide three times the maneuverability of the Razon. The Roc can be adapted for television and radio control and for target seeking.

Another technique of target destruction involved automatic release of all bombs in a squadron simultaneously, the planes being positioned in a formation giving a saturation pattern for the target of the day. The bombardier, in the lead plane, opened the bomb bay doors of all planes in the squadron by radio remote control and then pressed a button that automatically released all bombs. The transmitter in the lead plane was the ARW-9 (RC-186 modified), while the receiving equipment in all other aircraft in the squadron was the ARW-10, a modified version of the CRW-2.

Receiving Equipment

Tone-modulated remote-control receiving equipment generally consists of three separate units: the r-f receiver proper, the audio filter selectors, and the control relays. The circuit of one such equipment will be discussed in detail, and other equipments will be analyzed only insofar as they differ fundamentally.

The circuit of the model CRW-7 four-channel superheterodyne receiver is given in Fig. 1. This crystal-controlled receiver is capable of operating at any one of 47 predetermined frequencies, and was used primarily for Razon control during the war.

In operation, the tone-modulated r-f signal received by the antenna is amplified by the r-f amplifier circuit and then fed to the control grid of the mixer stage. The oscillator section employs a modified Pierce oscillator with an untuned grid circuit and with the plate circuit tuned to the third harmonic of the crystal frequency, followed by a tripler amplifier stage that applies the ninth harmonic of the crystal frequency to the mixer tube inductively by cathode injection. The mixer filament is connected in such a manner that it is at the same r-f potential as the cathode, eliminating the loading effect of the filament-cathode capacitance. The mixer plate circuit is tuned to the 15-mc i-f value. The gain of the first i-f stage is controlled by avc, while that of the second i-f stage is controlled by three factors—avc, a fixed bias tapped from a bleeder resistance, and the bias voltage developed across the cathode resistor.

One section of the duodiode is used for audio detection, and the other provides avc voltage for the r-f stage, the i-f stages, and the first audio stage. The output of the second i-f amplifier stage is also coupled through a capacitor to the plate of the avc section of the duodiode, making possible the desired avc voltage for the audio tube. Two stages of audio amplification follow the detector, with the output feeding a selective filter network. The four secondaries of this tuned audio transformer network respond to the audio frequencies of 475, 755, 1,900, and 3,000 cycles per second. Each filter output voltage is applied to the grid of a triode that is biased beyond cutoff and has in its plate circuit a relay which closes an electrical circuit to a mechanical actuator. A series resistor in the grid circuit prevents strong signals from causing excessive grid current. High grid current would load the filters, reducing the circuit Q and thus reducing filter selectivity on strong signals.

Rheostats in the plate circuits of the triodes permit adjusting channel sensitivity. Balanced relays are used, one for each twin triode. As long as no signal is applied, the relays will remain in a balanced condition. When a signal is received on a grid, the relay in that circuit will be unbalanced in one direction. If a signal appears on the other control grid of the same tube, the relay will be unbalanced in the opposite direction. In the balanced condition, relay contacts are set so that the mechanism controlled by the relay will return to a centered position. If the relay is unbalanced in one direction, the mechanism will be maneuvered off center position in a predetermined direction, and vice versa.

The model RC-57 superregenerative receiver employed in control of target aircraft for gunnery training purposes operates on any of four fixed carrier frequencies in the range from 68 to 73 mc, using the circuit shown in Fig. 2. The r-f amplifier stage is conventional, with slug tuning for the r-f coil connected to the nonresonant antenna. A self-quenching superregenerative detector similar to a Colpitts oscillator is used for detection.

Since the detector grid current is proportional to the incoming signal, the voltage developed is likewise proportional to the incoming signal. This voltage constitutes the audio output. As a result of grid blocking in the detector tube, a high level of quench voltage is developed, which

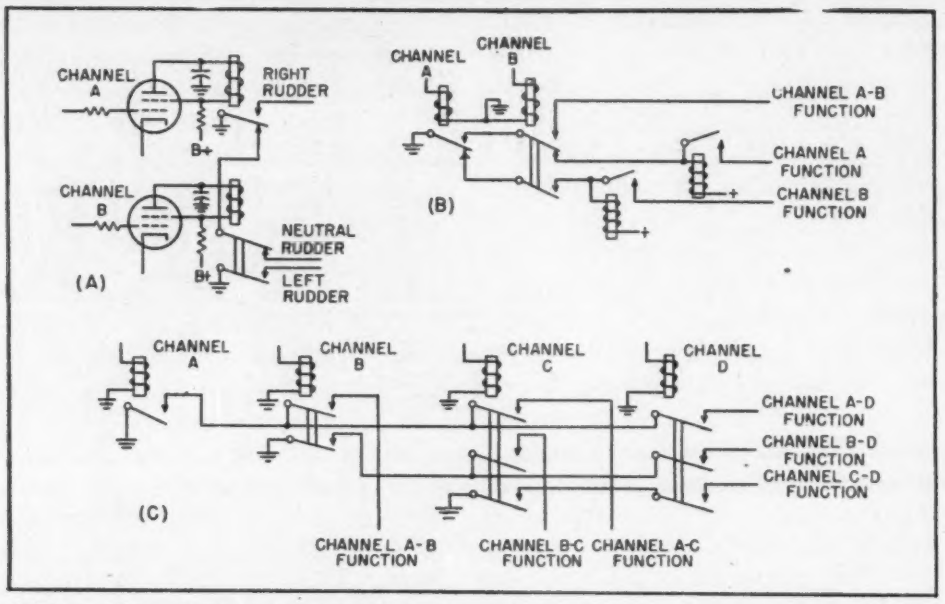


FIG. 3—Three basic types of relay arrangements for increasing the number of controllable functions obtained with a given receiver system

would normally accompany the detector signal output. This quench voltage is removed by a phase-shifting network to prevent overloading associated amplifiers and filter circuits. The a-f amplifier is essentially conventional, with regeneration in the first a-f stage making the gain at 3,000 cycles approximately twice that at 300 cycles. To equalize the response, a 0.001-microfarad capacitor is employed as a high-frequency bypass from plate to ground in the second a-f stage.

Five separate series-resonant *LC* circuits in parallel with the output of the second audio amplifier, each tuned to a different frequency, act as audio-frequency filters. Four of these tuned circuits are similar and have the signal fed through the tuning capacitor to the control grid of the particular relay-control tube. The fifth, for 650 cycles, is inverted so that the audio signal feeds through the inductance first, then through the capacitance to ground. This change reverses the selectivity characteristic and makes the 650-cycle filter less likely to respond to the next higher frequency.

When responding to its frequency, each filter builds up, through resonant action, a voltage sufficient to overcome the grid bias on its particular relay-control tube, enabling the tube to pass plate current and actuate the corresponding relay.

The model RC-64 f-m superheterodyne receiver used in guiding small target aircraft for gunnery training purposes operates in the 35 to 40-mc band, normally on one fixed frequency. The fourth harmonic of the crystal oscillator is combined with the incoming signal in the mixer to produce an intermediate frequency of 3 mc. The third i-f transformer feeds into the grid of the limiter tube, which acts to reduce any amplitude modulation due to static or noise impulses. The voltage developed by the limiter grid current is used for automatic volume control for the i-f and r-f stages. A conventional twin diode discriminator changes the frequency variations of the incoming signal to an audio frequency by means of a conventional discriminator network.

The discriminator output feeds into a two-stage audio amplifier that operates a carrier relay. The audio amplifier also feeds a paralleled group of ten relay triodes through *RC* filter networks that change the audio fidelity to offset the preemphasis introduced in the transmitter, with audio filters in each relay circuit responding only to the assigned frequency for that relay.

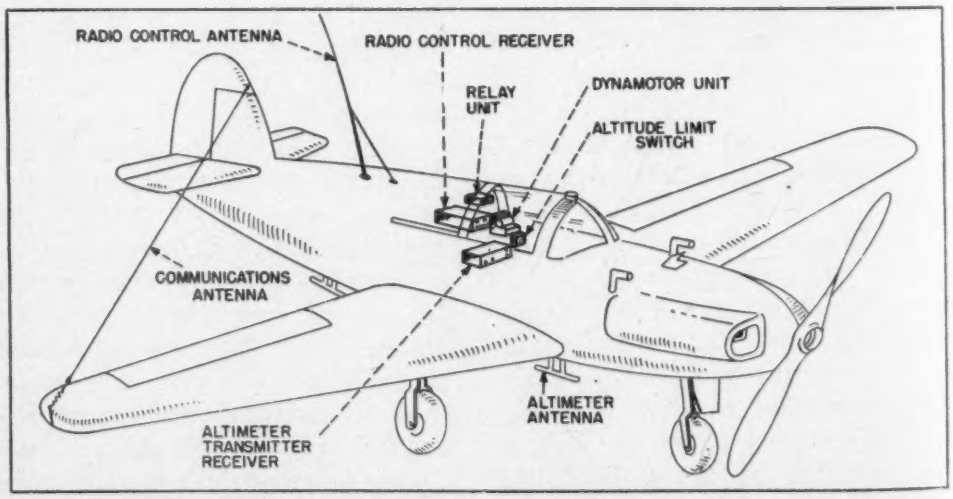
Superregenerative receiver CRW-2, designed for Azon bombs and automatic bomb release operations, is capable of receiving carrier frequencies between 50 and 100 mc. This range is covered by five sets of plug-in units. It is quite similar to RC-57 in operation and theory, but has only two audio channels.

Audio-Tone Control Systems

Various methods are available for increasing the number of controllable functions provided by an elementary receiver system. These may be divided into the following four categories: (1) single tone; (2) single tone and simultaneous dual tones; (3) dual tones; (4) single auxiliary step tones and single primary tone.

In the single-tone relay system a separate tone channel and actuating relay are required for each function performed. The output of the audio selector filter network channel is fed directly into a pentode which in turn actuates a relay that feeds a voltage directly to control surface mechanisms or to a gyro or servo for further interpretation.

By arranging relay circuits as in Fig. 3A, two channels can be made to perform three functions. Here a neutral position for the rudder (or any other such device) is provided when channels *A* and *B* are not operating. No neutral position is pro-



Low-wing PQ-14 target aircraft using f-m radio control receiver ARW-1. With a speed of 160 miles an hour, this plane can be maneuvered to simulate strafing

vided for the elevators of the OQ targets, however, inasmuch as a change in the plane's center of gravity due to normal fuel consumption will make the plane rise or dive of its own accord and therefore require constant correction.

Removal of the carrier frequency makes possible an additional function if desired. This is actually employed with one variety of target aircraft, where the parachute is automatically released when the carrier is removed.

In the single tone and simultaneous dual tone system single tones and single relays accomplish one function each, and simultaneous combination of two tones accomplishes still another function which is not related to either of the functions produced by the single tones. The basic circuit is given in Fig. 3B.

The relays in series with the outputs of the *A* and *B* channels are safety devices that act as time-delay relays (about 5 milliseconds) to allow for any minute differences between the start of the two tones at the transmitter. If this precautionary measure were omitted and either of the two channels should operate separately when a dual-channel function is implied, the single tone action would be performed and in some cases (supposing it were the detonate channel) there would be disastrous results.

The dual-tone system always requires simultaneous transmission of two tones to perform a single function. While the four-channel circuit shown in Fig. 3C gives six functions, a five-channel system would provide 10 functions and a six-channel system would make possible the control of 15 different aircraft functions. Safety time-delay relays are not needed.

In the system employing single auxiliary step tones and single primary tones a single auxiliary tone is used to position a stepping relay which selects the desired function, and another primary tone is used for actually accomplishing the movement. A reset channel tone releases a cam on the selector switch, allowing the selector to swing back to its starting position.

The third portion of the system consists of four primary tones which are only used to control the control surfaces (right or left rudder, elevators up or down). It would be undesirable to refer these basic flight functions to a selector switch of this type.

Pulse Control Techniques

Methods other than tone control have been utilized to transmit intelligence to guided missiles. One of these methods is pulse control by the use of radar. The radar transmitters are usually keyed at an audio rate. If, however, provisions are incorporated in the design of the transmitter to provide a variable audio rate of pulsing, then a receiver with suitable audio filters can select these audio transmissions and convert these impulses into desirable control functions through relay boxes.

Pulse control development has been conducted using primarily uhf transmitters, which necessarily limit the range at which control can be effected to line-of-sight distances. This system could be applied as well to lower-frequency transmitters where space and weight considerations for both transmitter and receiver are not primary factors.

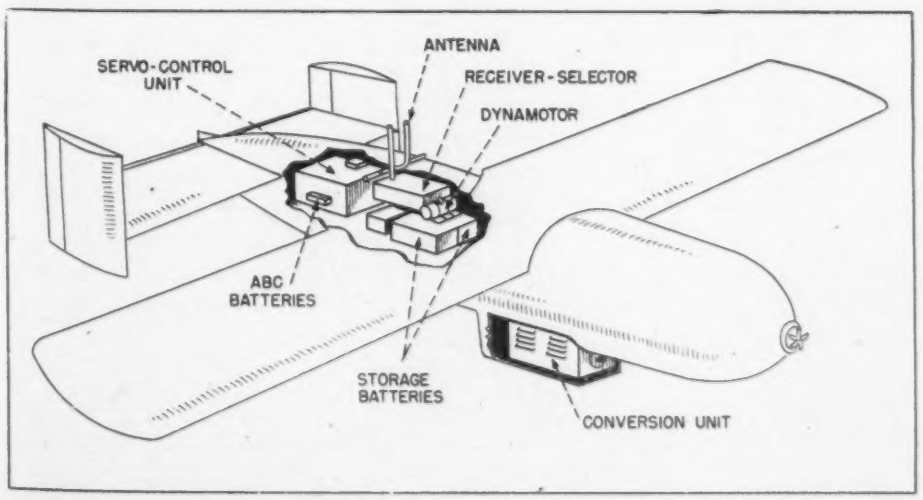
The security of a single pulse control system is not adequate for modern warfare, since an aggressive enemy through active monitoring can easily determine not only the system which is in operation but also the type of intelligence that is being transmitted over the system. A coded pulsing system will materially add to the security of the system; however, such a system with single or coded pulses is susceptible to jamming, becoming more and more unreliable as the receiver in the missile approaches enemy territory.

Work is continuing on an expanded guided missiles program, involving detailed consideration of means for automatically accomplishing the takeoff, control, navigation, and final trajectory on a basis similar to that employed by bomber aircraft on missions.

Future Guided Missiles

It is still too early to describe in detail the technical aspects of this program. There is, however, a basic philosophy for the guidance of missiles which will be pursued on a long-range basis, namely, assurance of positive control throughout the life of the missile together with means for availability of missile progress data at the remote launching point. This second phase is perhaps the most difficult as it involves the transmission of video-type signals over distances beyond radio line-of-sight without the benefit of airborne relay stations. This problem may be met through various concessions in the solution of special military problems.

This article has presented most of the more important guided missiles developed by the Army Air Forces during the past war, and indicates certain aspects of future development trends. Limitations which are being considered and eliminated are range, speed complexity, traffic-handling capacity, and vulnerability to countermeasures.



Radio-controlled glide bomb known as Glomb, controllable from Mother aircraft at distance up to 17 miles from target

Dynamic Suppression of

By controlling the bandwidth of an audio amplifier automatically in accordance with the characteristics of the recorded music, suppression of high and low-frequency noise may be achieved without noticeable injury to the realism of reproduction

THE MOST OBVIOUS shortcoming of ordinary reproduction of music from phonograph records is the presence of the high-frequency background noise level caused by minute irregularities on the surface of the record. Although this noise is more or less random in character, the most annoying part of it is concentrated in the same frequency range as the upper musical harmonics. Any attempt to reduce it has heretofore been accompanied by a serious attenuation of these harmonics and often of some of the higher musical fundamentals also.

For years, it has been recognized that the most satisfactory simple means of controlling noise is by controlling bandwidth, using as sharp a cutoff as possible beyond the desired band and a minimum of attenuation within the band. The reproduction of phonograph records represents about the only phase in the field of electrical reproducing where this precept has been generally disregarded. There are several reasons for this. One is that the commonly used crystal pickup, when operated into a high-resistance load, provides conveniently a drooping frequency characteristic or high-frequency rolloff without the use of any additional parts. Another is that phonograph records have been made with various degrees of high-frequency preemphasis, and a single tone control adjusting the rate of rolloff can be used either to compensate for the recording characteristics or to reduce noise, the latter of course always at the expense of fidelity. The third and perhaps most important reason is that a sharp cutoff frequency sufficiently low to reduce the noise level appreciably makes such a deep excursion into the range of lower overtones and higher fundamentals of the music as to produce an extremely unnatural and mechanical quality at high volume levels.

To a secondary degree there are also present low-frequency noises or rumbles, which may be in either the record or the turntable, and which are noticeable during soft passages which do not contain many low frequencies. The present tendency to use large amounts of bass boost or automatic low-frequency compensation greatly exaggerates any rumble that may be present.

High-frequency and low-frequency noises are present at substantially constant level during the playing of a record. Hence they are most noticeable during soft passages and least noticed (often masked completely) during loud passages. The noise suppressor described in this paper is a device which controls the bandwidth of reproduction automatically and continuously as a function of the volume and frequency characteristics of the music, extending the band during the loud passages and contracting it during the low-level portions, the variation in bandwidth being independently controlled at both ends of the spectrum. Thus the noise is reduced when it would be most noticeable, and full bandwidth is used when it is most necessary, at high levels. This automatic contraction and extension

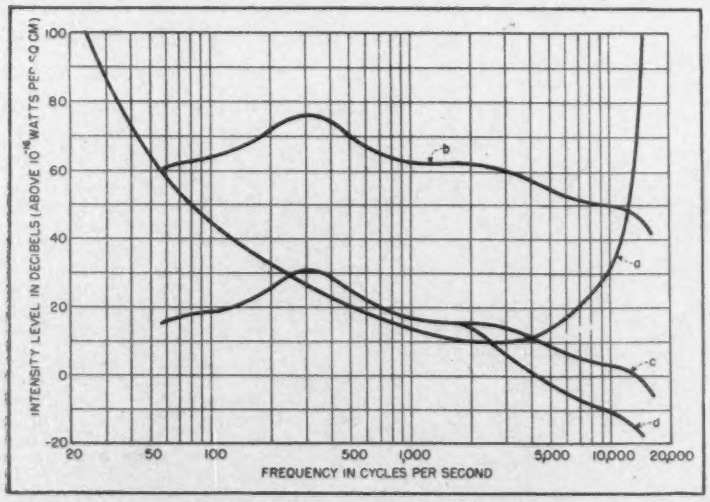


FIG. 1—Typical threshold of hearing (a) and most probable distribution of frequency components in music at high levels (b), with volume control turned down (c) and with orchestra playing softly (d)

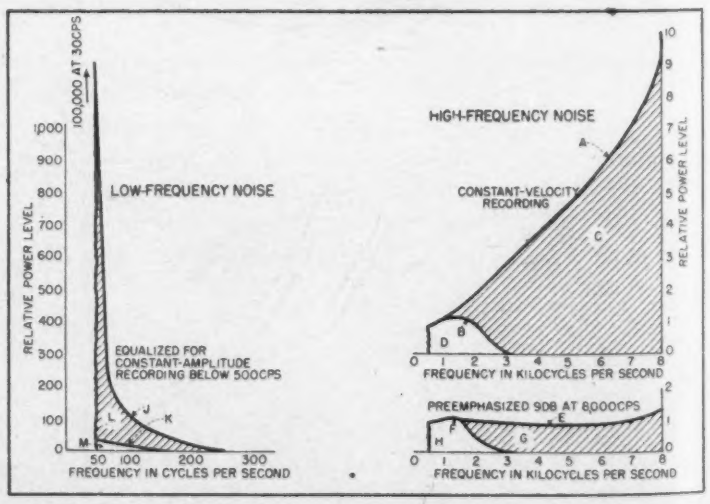


FIG. 2—Relative noise level per cycle bandwidth at high and low frequencies, when reproducing shellac records with and without dynamic noise suppressor. Shaded areas represent degree of noise reduction

Phonograph Record Noise

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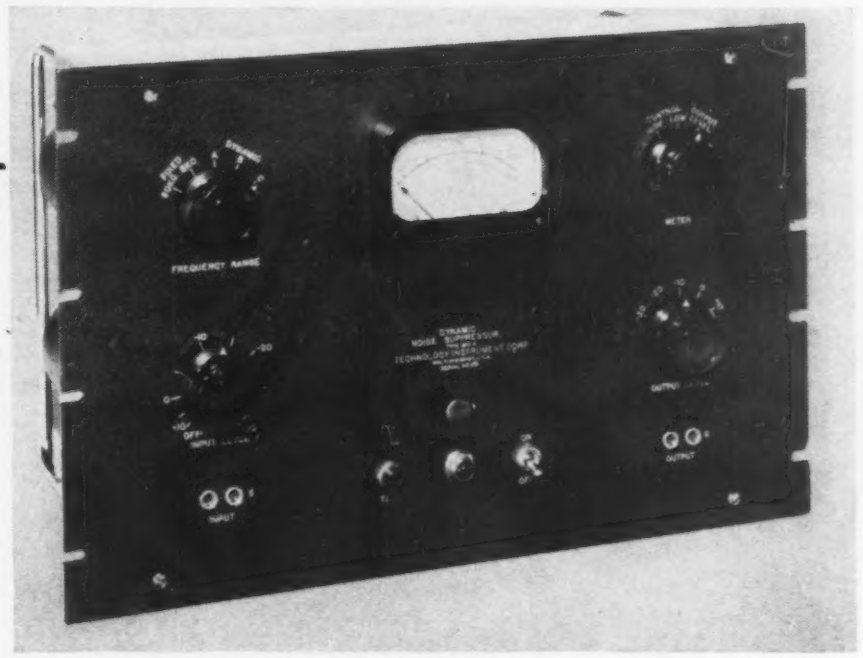

Dynamic noise suppressor designed particularly for broadcast station use

of the bandwidth has but a negligible effect on the apparent realism of reproduction, because of the threshold characteristic of the ear and the distribution of energy in musical sounds as described below.

Music and Hearing

Curve *a* in Fig. 1 shows the threshold of hearing[1] for an average person, in terms of frequency. Sounds below this curve are inaudible. The distribution of the most probable amplitudes of the various frequency components involved in typical orchestral music[2] is shown by curve *b*. This may be moved up and down by varying the volume level of the reproduction as shown in curve *c*, but it will be noted that it always intersects curve *a* at definite points in both the low and high-frequency ranges. For any particular position of curve *c* and for the type of signal represented by curve *c*, all frequencies above and below these high and low-frequency limits, respectively, may be neglected so far as being of any importance to the listener is concerned, since he will not be able to hear them.

As a practical matter, if the reduction of volume is obtained by the musicians playing more softly, the shape of curve *c* will actually be altered to something more like curve *d*, showing still greater reduction in amplitude at the higher frequencies. This is the result of the well known fact that most musical instruments produce purer tones (less harmonics) when played softly than when played loudly. It will be noted that at low levels curve *d* may cross the threshold curve at a high-frequency limit as low as 2500 cycles.

Theoretically, then, when listening to low-level orchestral music of the type indicated, insertion of a 2500-cycle low-pass filter will produce little or no change which is obvious to the listener. This is actually borne out by listening tests. But the introduction of the filter results in a tremendous decrease in needle scratch. This is true because most of the scratch noise is high-frequency noise and its level is well above the threshold of hearing.

A similar situation exists at the low-frequency end of the range. Here again, reproduction of those components which fall below the threshold of hearing results in no worthwhile improvement in the quality of the signal but may cause rumble noise which is considerably louder than the desired signal components.

If, therefore, some system is devised which automatically cuts off sharply in response characteristics for the ranges including those components of a signal which are at too low a level to be heard, the apparent quality of reproduction will not suffer, and the signal-to-noise ratio will be improved to a worthwhile degree. The present state of the electronic art allows practical accomplishment of this objective in several different ways, with varying elaborateness of equipment.

Degree of Noise Reduction

The amount of audible noise reduction obtained with the system under discussion is difficult to express in simple terms, since it depends so much upon the high-frequency hearing of the individual, the effect of auditory masking of the small remaining noise by the music signal, and various psychological factors dealing with annoyance and personal preference.

A relatively simple system can be made to give more than 20-db attenuation to high-frequency and low-frequency noise, with substantially no attenuation within the pass band. A narrow band of noise is all that is left, and it is so situated (in shellac records) that it coincides with the point of minimum noise energy. It also lies within the musical spectrum, so that it is easily masked by even low-level music. In general terms, it may be said that the suppressor reduces the noise level from a point where it is distinctly annoying to a point where it is practically eliminated on the best records and prac-

tically unnoticeable on the worst records.

The only fair proof of the effectiveness and true value of the dynamic noise suppressor is in actual listening tests. Figure 2 has been prepared in an attempt to give a graphical portrayal of the amount of noise reduction. Curve *A* represents typical noise level per cycle bandwidth on a standard-grade shellac record.[3] The variation among records is very great, and while some high-quality records, particularly of the Vinylite type, may be noticeably quieter, many records, particularly if at all worn, produce far higher noise levels in the high-frequency range.

Curve *A* represents the relative noise level at various frequencies in terms of power level, as reproduced with a flat overall characteristic from a constant-velocity recording. The total area *C* plus *D* under curve *A* represents the total noise, since a linear frequency scale is used. Similarly, curve *B* represents the remaining noise spectrum when using the dynamic noise suppressor and the area *D* under this curve represents the remaining noise energy. Visual comparison of the area *D* with the total area *C* plus *D* gives some idea of the amount of noise reduction obtained on the physical basis of overall noise energy. It will be noted that the area *C*, representing the amount of noise eliminated by the dynamic noise suppressor, comprises all but a very small portion of the total noise energy, and that the most annoying noise, which occurs in the higher frequency ranges, is eliminated entirely.

Preemphasized recordings have been used increasingly in recent years as a means of obtaining an improved signal-to-noise ratio. While record companies have not published data as to the exact amount of preemphasis used, indications are that 9 db at 8000 cycles is typical of records which have been widely sold. If the reproducing system is provided with an equivalent amount of deemphasis, the curve *A* becomes the curve *E*, and curve *B* becomes curve *F*. The total area *H* plus *G* represents the total noise, while *G* represents the relatively large proportion eliminated by the suppressor and *H* is the relatively small amount of remaining noise, which is even smaller than the equivalent area *D* without preemphasis.

Figure 2 shows also the low-frequency noise taken from Bauer's data (which were on a constant-velocity basis), adjusted for the normal reproducing characteristic used with a 500-cycle turn-over point between constant-amplitude and constant-velocity recording. It should be noted that the scales for the low-frequency chart are different from the high-frequency charts in order to provide satisfactory illustration of the noise-reduction effect. The break between the low and high-frequency charts was positioned at 500 cycles, which is a conventional crossover point in recording characteristics. It will be noted from curve *J* that low-frequency noise increases rapidly below 200 cycles, reaching a power level 1000 times as high at 50 cycles as at 1000 cycles, and still 100 times higher at 30 cycles. This illustrates why many record-reproducing systems have incorporated low-frequency cutoff circuits to reduce rumble trouble and acoustic feedback.

The action of the noise suppressor is the opposite of the low-frequency noise characteristic in that the noise attenuation increases as the frequency is decreased. Consequently, the remaining noise is approximately as shown by curve *K*, and is negligible at even very low frequencies. The total area *L* plus *M* represents the total low-frequency noise, the area *L* being that eliminated by the suppressor, and the area *M* representing the remaining noise. It will be noted that *M* represents a negligible part of the total noise area. Use of the suppressor is consequently of tremendous benefit in systems having extended or boosted bass response, and the suppressor becomes more important as the bass response is improved.

Aural Balance

There is a further important advantage in the simultaneous control of the low and high frequencies which is totally independent of the noise-suppression effect but is of prime importance in presenting what to the ear appears to be constant reproduction of a wide frequency range.

It is well known that restriction of one end of the frequency range is less noticeable if the other end of the range is also restricted, thus maintaining substantially constant the product between the high-frequency and the low-frequency cutoffs of the system. Of course, if the noise-suppression system were perfect, and the frequency ranges attenuated always fell beyond the range of audibility, the question of maintenance of aural balance would be of no importance, since, so far as the ear could determine, there would be no restriction of the frequency range. As a practical matter, however, this theoretically ideal condition is not always obtained.

Many people like to operate their radios or phonographs at a fairly high level, and, particularly where a high degree of compression is used in the transmission or the recording, the low-level portions of the program may be heard at a higher level than normal. This is also true for people sitting unusually close to the loudspeaker when the volume is adjusted for satisfactory level in a fairly large room. Under either of these conditions, the range during the low-level portions of the program may be restricted somewhat within the audible limits. Also, all program material will not follow exactly the actual frequency distribution of the curve *d* of Fig. 1. In fact, the actual frequency distribution of the music is constantly varying not only from orchestra to orchestra or from instrument to instrument, but also from instant to instant. Any curve such as those of *c* or *d*, therefore, represents merely an average condition.

Since these particular curves are based upon most probable levels, variations will normally fall below the curves, but occasionally variations will fall above the curves, and under these conditions also, if the variations occur at very high or very low frequencies, the aural bal-

ance might be upset. Independent control of low-level high-frequency cutoffs provides best fidelity for a wide range of signal types and best aural balance for variations in listening conditions.

A third condition goes back to the generally accepted reaction of the average listener in regard to noise versus high fidelity. Under conditions where a choice between fidelity and noise must be made, the listener will generally choose that condition which keeps the noise level practically inaudible during the actual program. With extremely noisy records, this may make desirable the setting of the control and gate circuits so as to provide somewhat greater frequency-range restriction, particularly at low levels, than that implied from theoretical considerations of curves *a* and *d*.

These conditions indicate the desirability of a system controlling both low and high frequencies, a desirability sufficiently great, in fact, to warrant control of both ends of the frequency spectrum even under conditions where noise is encountered at only one end.

Gate and Control Circuits

The heart of the noise-suppression system is a controlled bandpass filter known as the gate circuit. It has extremely sharp cutoff characteristics, particularly for the elimination of high-frequency noise. For varying applications, depending upon the type of signal and the type of noise, lowpass, bandpass or band-elimination characteristics may be desired. For the disc record application a bandpass characteristic is preferred, with a sharp cutoff at the high-frequency end. The sharpness of the low-frequency cutoff is of somewhat less importance, but a slope steeper than that obtained with the ordinary single-stage R-C tone control is desirable. The gate circuit is capable of rapid control without introducing audible thumps into the output.

The control circuit which actuates the gate circuit adjusts independently and continuously both high and low cutoffs of the system, so that they always coincide with the respective points of intersection of the curves for the threshold of audibility and the frequency distribution of the particular signal. The control must be sufficiently fast to permit satisfactory reproduction of transient sounds and to follow each individual note in the music, so that noise shall not be heard in the background between adjacent notes in music of a staccato or percussion character, such as from the piano. When properly operated, the system shows no noticeable evidence of a rising and falling background noise varying in accordance with the musical signal.

The noise levels encountered in the upper and lower frequency ranges over which the cutoffs may be varied are considerably higher than the musical components existing in those ranges, except during a small portion of the playing time. Consequently the sensitivity of the control circuit must be reduced in the ranges over which the cutoffs are controlled in order that control shall reside in the signal, rather than in the noise or rumble. This is very satisfactorily arranged when the reproduced signal is music, since the extremely high harmonics exist only with fundamentals of somewhat lower frequency, and control of the high-frequency cutoff can be exercised in accordance with musical components below the controlled range. Similarly, the deep bass fundamentals are accompanied by harmonics of appreciable amplitude which may be used to control the low-frequency cutoff.

Practical Equipment

The noise suppressor for home phonograph use involves only three vacuum tubes, two in the gate circuit and one in the control circuit, and this third and latter tube may often be combined with one of the tubes already in the set. Furthermore, the gate circuit may be made with an adjustable maximum bandwidth or rolloff and thus may be used to replace some of the usual tone-control circuits in the receiver and the 10-kc whistle filter for a-m reception, so that the additional parts required to include the suppressor in a radio-phonograph are few in number.

Further elaboration of the gate and control circuits will produce many advantages such as wider frequency range, lower distortion, lower hum level, greater flexibility of control, and the ability to cope satisfactorily with a wider range of signal and noise types. The first three of these characteristics are of relatively little importance in home radio-phonograph, since even the simpler circuits exceed the normal requirements of home radio-phonograph design in these respects. The other improvements involve too many extra parts and tubes for inclusion in the average home receiver. On the other hand, for broadcast applications, the best possible performance is more important than the actual cost of the equipment, and for these applications, a considerably more elaborate form of the noise suppressor has been designed and is pictured here.

Details of the circuits will be published in an article to appear in these pages as soon as patent actions are completed.

CIRCUITS TO COME

For patent reasons, the author has found it necessary to omit circuit diagrams from this paper.

In view of the great interest aroused by demonstrations of the dynamic noise suppressor at the National Electronics Conference, the editors feel that this description of the underlying principle should nevertheless be published.

Mr. Scott has promised complete details of both broadcast-station and home equipment for publication in an early issue.

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(2) Prepared by Ralph P. Glover, based upon data published by the Bell Telephone Laboratories. See also "Frequency Range and Power Considerations in Music Reproduction", published by the Jensen Radio Mfg. Co., and Harvey Fletcher, Hearing, the Determining Factor for High-Fidelity Transmission, *Proc. IRE*, 30, p 266, June 1942.

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VIBRATION EXCITER for Structural Tests

Electromagnetic shaker units develop tremendous forces at mechanical resonance, for aircraft flutter tests and failure tests in structural members. Unique carrier-type a-f amplifier, phase shifter, and phase indicator circuits are employed

By PAUL J. HOLMES

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THIS electronic vibration exciting equipment was primarily designed for making flutter tests on large aircraft structures. It provides for separately exciting vibration at each mechanical resonant frequent of the structure being tested, as contrasted to brute-force apparatus wherein vibration is created through use of a rotating unbalanced mass driven by a constant-speed motor.

In comparison with a mechanical system for producing vibration, the electronic method offers flexibility and accurate control over the vibration forces being applied. When desired, vibration forces may be exerted simultaneously at several points on a structure. The operator has fingertip control over the phase and amplitude relationships of the several vibration forces being exerted, permitting excitation of torsional or bending modes of wings, either symmetrical or antisymmetrical, at will.

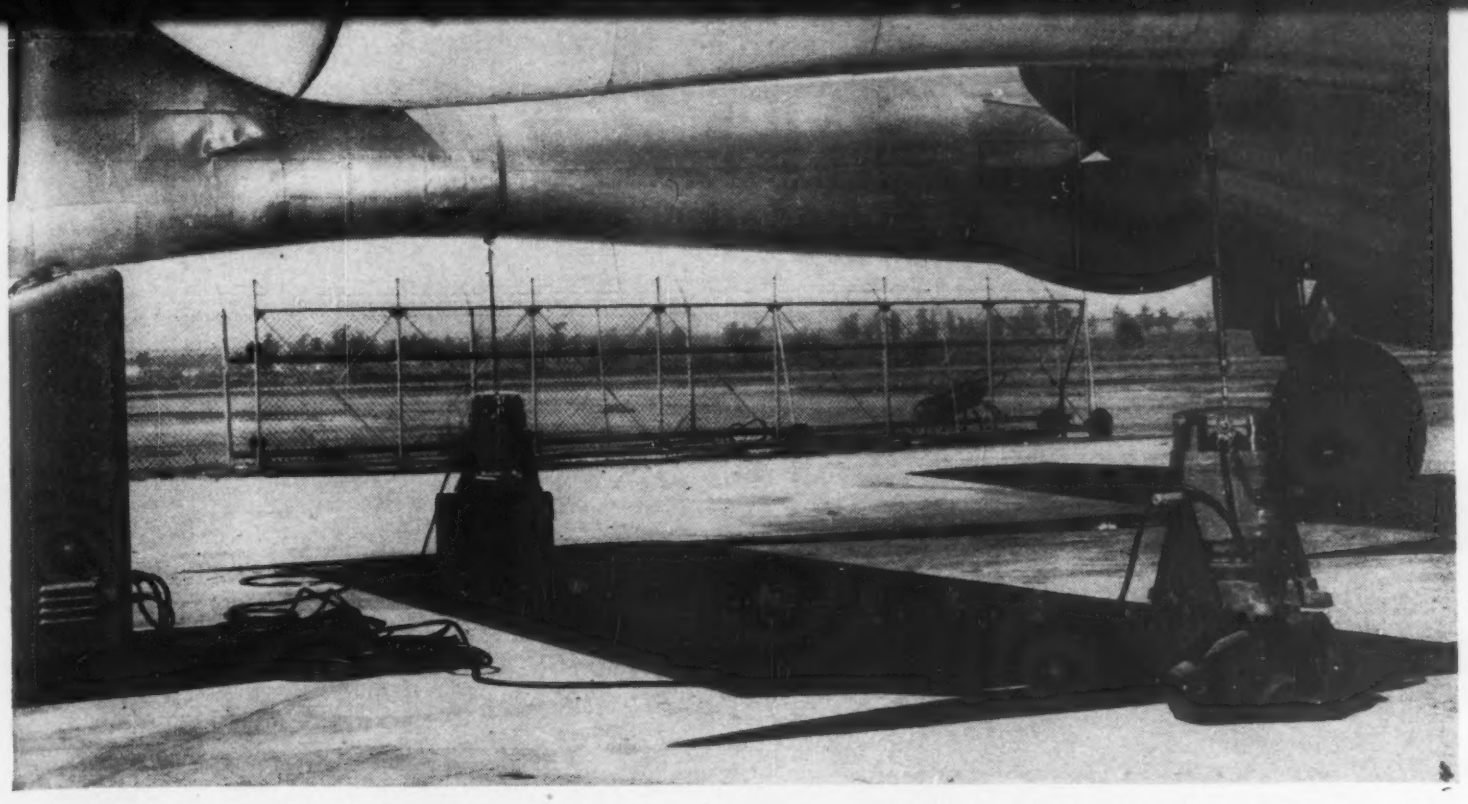
As an example, the Douglas C-74 (DC-7) airplane was caused to bounce vertically on its landing gear by applying vibration exciting forces to the wings, adjacent to each side of the fuselage. The mass of the airplane (30 tons) and the compliance of the tires resonated at a frequency of 114 cycles per minute. Two electromagnetic shakers were used and the peak force required to produce the vertical bounding was only 45 pounds per shaker. Thus, tremendous mechanical forces can be developed through the phenomenon of resonance.

In another test, the wing of a large airplane was excited in an anti-symmetrical bending mode. This imparted a torsional (rotational) motion to the fuselage, causing the tail assembly to whip from side to side. The extent of tail motion made the fuselage oil-can and produce snapping sounds like those of a child's metal cricket.

Many of the recent types of aircraft, both large and small, have been tested with the Rollin model 35 equipment described, including the Consolidated Vultee XB-36 (the Army's largest land-based bomber), the Northrop XB-35 flying wing, Douglas C-74, Northrup XF-15, and the Consolidated RY-3.

Complete vibration exciter equipment for driving the two pairs of electromagnetic shaker on the floor. Power amplifier cabinet at left contains plug-in a-f oscillator for controlling exciting frequency of shakers, while cabinet at right contains plug-in phase shifter for varying phase relationship of signals fed from a-f oscillator to the two power amplifiers. Extra a-f oscillator on box between cabinets is plugged into cabinet at right in place of phase shifter when it is desired to use the two amplifiers independently, each with its own controllable a-f oscillator and pair of shakers

The use of the equipment is not limited to testing airframes, however. It may be employed to excite vibration in various types of structures, such as for making accelerated repeated load or fatigue tests (to the point of failure or destruction) to determine the physical properties of various structural members or certain materials. For instance, a resonant force of 200 pounds may be exerted alternately in tension and compression on a sample structural member for 80,000 cycles in two hours. A similar test employing motor-driven cam-operated apparatus operating at the rate of 10 cycles per minute would



Power amplifier cabinet just showing at left supplies exciting power to the two shakers on the ground, each attached to one of the fuselage sections of a Northrop F-15 photo reconnaissance plane

require well over 100 hours of running.

Electromagnetic Shaker Units

The driving force is produced by electromagnetic vibration motor or shaker units energized by a vacuum-tube oscillator and power amplifier. The frequency of the oscillator can be controlled over a range from 2 cycles per second (120 cpm) to over 500 cycles per second (30,000 cpm), and lower frequencies down to zero can be obtained by substituting a motor-driven sine potentiometer and a battery for the vacuum-tube oscillator.

A shaker unit comprises a movable armature coil suspended in the air gap of a magnetic circuit operated at high flux density. The field coils are wound with 100 pounds of copper wire. The complete shaker weighs about 225 pounds and can produce a peak blocked driving force of 150 pounds. A mechanical connection to the armature transfers this force to a structure.

A unique beryllium copper suspension system keeps the armature coil centered in the air gap during motion while permitting an armature excursion of over $\frac{3}{4}$ inch in both directions from the rest position. Less than 5 pounds of pull is required to move the armature from its rest position to a position of maximum excursion. This spring system has low mechanical damping as required for observance of weak resonant periods of vibration in the structure under test, and the mass of the driving element (primarily that of the armature coil) is low enough so it does not affect the resonant periods of the structure. Another requirement, minimum electrical damping, is obtained by keeping the internal resistance or impedance of the source of driving power (the amplifier output stage) high with respect to that of the armature coils. With a higher resistance, the back emf generated by armature coil motion cannot cause appreciable current flow which would constitute an electrical damping effect.

Many vibration tests require means for applying vibration forces of different phase to two points on a structure, such as for creating torsional (rotational) types of vibration. For this reason two identical exciters are provided, each in its separate cabinet and driving its own pair of shakers. The block diagram in Fig. 1 shows interrelationships of the two cabinets. If only one pair of shakers is required one cabinet and the phase shifter are disconnected, and the audio oscillator is fed directly into the other cabinet. The unused

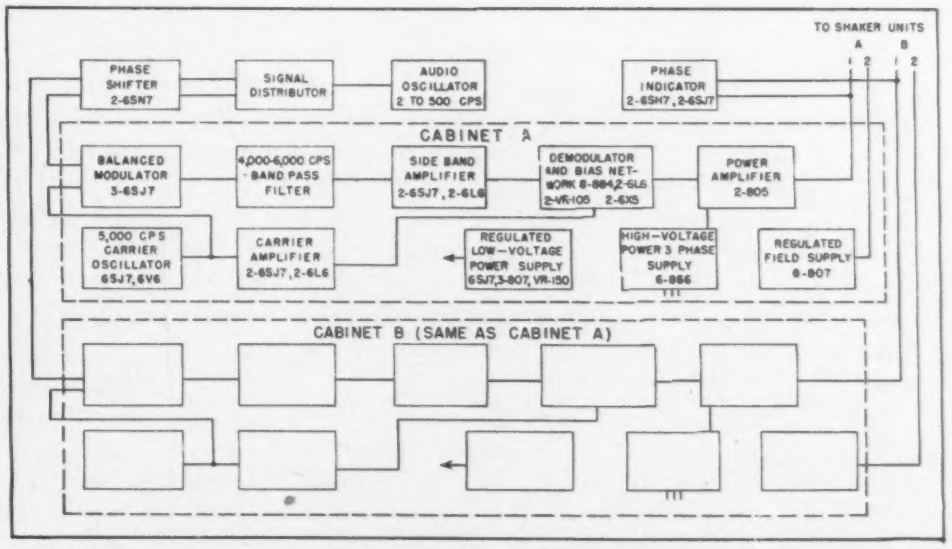


FIG. 1—Block diagram of complete vibration exciter equipment for driving two pairs of shakers

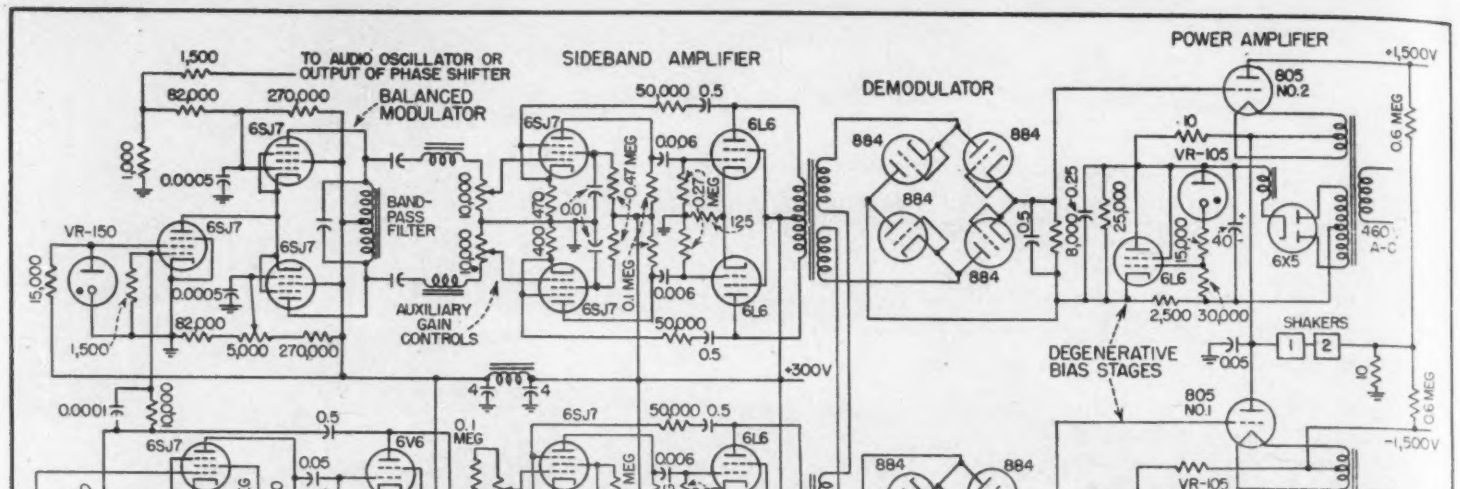


FIG. 2—Circuit of carrier-type power amplifier used for driving one pair of shakers

units serve as standby sets, a desirable feature since interruption of tests on a large airplane is quite expensive.

Operation of Exciter

Consider first the simplest setup whereby the audio oscillator is feeding directly into the balanced modulator of cabinet A in Fig. 1 and cabinet B is unused. To achieve satisfactory amplifier performance from 500 cycles down to zero frequency, a carrier system is employed and the class B output stage is of the cascade type. No output transformer is used.

The low-frequency signal from the 2 to 500-cycle oscillator (or from a still lower frequency motor-driven sine-wave generator) and a 5,000-cycle signal from the carrier oscillator are directly impressed on a novel degenerative type balanced modulator which will function to zero signal frequency and is extremely stable in operation. The modulator suppresses the 5,000-cycle carrier and creates sum and difference components in the output. The low-frequency signal (2 to 500 cycles) is also in the output, but is eliminated by a 4,000 to 6,000-cycle bandpass filter. The resulting desired sideband components are amplified in the sideband amplifier. The output from the carrier oscillator is separately amplified in another identincal amplifier.

The amplified outputs appear in transformers which have dual output windings. At this point the sidebands are recombined with the carrier so normal modulated envelopes are produced. A phase correction network (not shown on the block diagram) located between the carrier oscillator and the balanced modulator provides for proper phase between the carrier and sidebands when recombined.

The dual output windings feed separate demodulators 180 degrees out of phase, so that the demodulator output signals are suitable for driving the grids of the class B output tubes which drive the shakers.

Exciter Circuit

The complete circuit for driving one pair of shakers (housed in one cabinet) is given in Fig. 2. In addition to the low-frequency signals, the outputs of the demodulators contain a d-c voltage due to the carrier. This voltage would continuously bias the grids of the output tubes if it were not balanced out by an opposite bias voltage. Unique degenerative bias networks serve this purpose and also function as sources of d-c bias voltage which remain constant regardless of grid current flow through them.

The grids of class B tubes draw considerable current when the impressed signal is positive. Such current flow tends to increase the

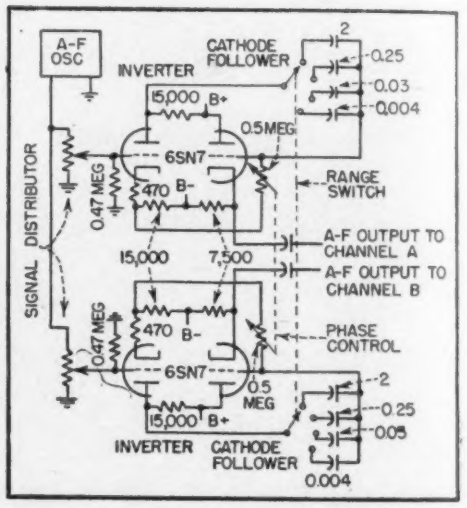


FIG. 3—Circuit of phase shifter used between a common a-f oscillator and two power amplifiers when it is desired to drive two pairs of shakers in various phase relationships ranging from zero to 360 degrees

voltage across a bias network but the action of the degenerative network is to maintain the bias at a nearly constant value. Because of this grid current flow, the output impedance of the demodulators must be quite low and have good regulation. The low impedance is obtained by employing for the demodulators a bridge circuit using type 884 rectifiers and by having considerable negative feedback in the sideband and carrier amplifiers.

Power Supply Circuits

The design of the power supplies is more or less conventional. Three-phase 460-volt power is employed

because the rectified output from the power supplies is then simple to filter and gives good regulation as required for low-frequency amplifier operation. The positive and negative high-voltage supplies for the type 805 output tubes are obtained from two Y-connected three-phase half-wave rectifier circuits employing a total of six type 866A tubes. In extremely low-frequency amplifier operation, the instantaneous peak plate current of the output tubes (750 milliamperes) becomes substantially a static current and the high-voltage power supply is designed to supply this peak current continuously.

The low-voltage power supply employs a three-phase half-wave circuit using three type 866A rectifier tubes. Its output is filtered and fed to an electronic voltage regulator which in turn supplies plate voltage to all vacuum tubes other than the type 805 output tubes.

Current Regulators

The rectified and filtered output of the low-voltage power supply is also fed to two electronic current regulators which supply all necessary field current to the shaker units. Each current regulator comprises three type 807 tubes connected as pentodes and used as constant-current devices to supply a controllable field current to its shaker units and hold the current constant despite changes in field coil resistance during heating.

A resonant type constant-voltage transformer connected to one phase of the three-phase 460-volt power line supplies regulated 115-volt a-c power for the 2 to 500-cycle oscillator. This oscillator has a feedback circuit with a very low time constant and sudden variations in line voltage would cause low-frequency transients.

Phase-Shifter

For dual operation with cabinet A and cabinet B, the setup is as shown in Fig. 1. Each phase-shifting network in the phase shifter employs a dual-triode vacuum tube connected as in Fig. 3. The first section serves as a phase inverter to obtain equal voltages with respect to ground which are 180 degrees out of phase. Across the output terminals of the phase inverter is a series-connected *RC* network whose junction point goes to the grid of the second section of the dual triode, which is connected as a cathode follower.

The phase-shifted voltage at the grid of the cathode follower is the vector sum of two voltages whose magnitude and angle both change as the variable resistance of the *RC* network is changed. The magnitude of the resultant of these two voltages remains constant in amplitude while the phase angle is changed from zero to very nearly 180 degrees. Thus, the output of each cathode follower supplies a voltage whose phase may be continuously shifted by means of a variable resistance.

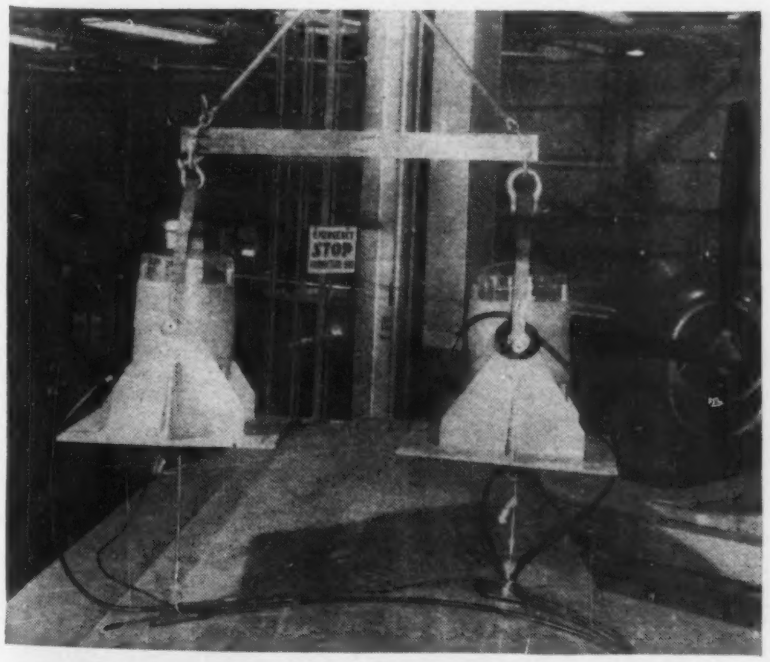
Signal Distributor

The signal distributor used between the phase shifter and the a-f oscillator provides for continuously varying the amplitude relationships of the forces exerted by the pairs of shaker units. With this control one pair of shakers can be caused to produce a low driving force while the other pair is producing a high driving force, and vice versa, or an equal driving force can be had from both pairs of shakers. Overall control of the forces is provided by a master control on the 2 to 500-cycle oscillator.

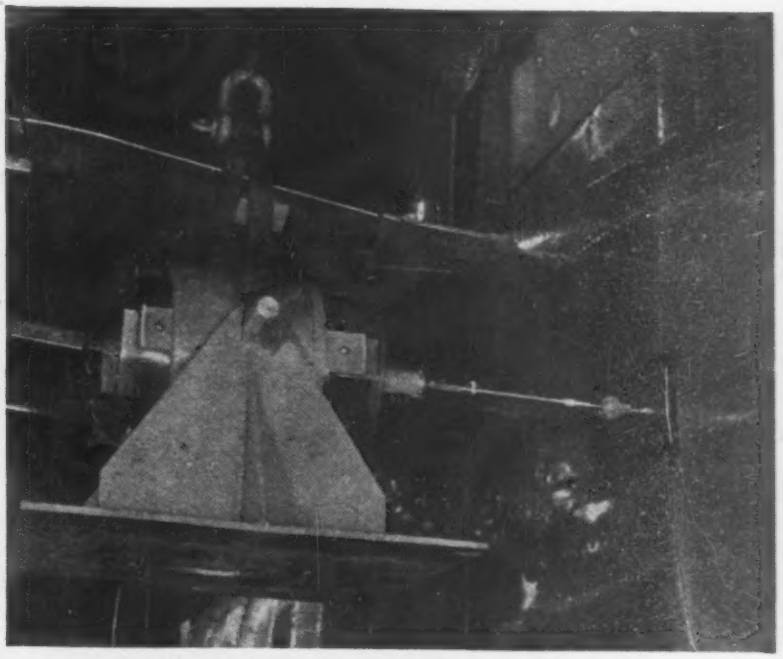
The variable resistances of the two phase-shifting networks are ganged to provide concurrent adjustment, advancing the phase in one output while retarding the phase of the other. The phase relationship can be adjusted from 0 to nearly 360 degrees in this manner.

Phase Indicator

The phase indicator (used only for dual operation) indicates phase differences of from 0 to 360 degrees on a calibrated linear scale, with the 180-degree point occurring



Setup of two shakers for wing vibration test of Consolidated Vultee model RY-3 airplane



Setup of single shaker for fuselage side bending test on Consolidated Vultee model RY-3 airplane

exactly at midscale. Continuous indication of phase is obtained, substantially independent of frequency over the range of from 2 to 500 cycles and very nearly independent of the amplitude relationship of the signals being compared for phase.

The circuit of the phase indicator appears in Fig. 4. In operation, a constant amplitude of current flows through the indicating meter for a time period determined by the crest point of the negative half-cycle of one signal and the corresponding point on the other signal. No current flows through the meter until the starting point of the first-mentioned signal again occurs. The repetition rate of current flow through the meter is determined by the frequency of the signals being compared. These on and off periods of current flow are primarily a function of the phase difference of the signals being compared. The ratio of these periods is independent of frequency. The deflection of the pointer of the indicating meter is directly proportional to the ratio of the on-off periods of current flow. Because of this, a linear phase indication is obtained.

A flip-flop or trigger circuit provides the on-off periods of current flow. Each side of this circuit is separately triggered by a spike or pip obtained from a differentiation network fed by a two-stage limiter amplifier. The two limiter amplifiers resolve each of the impressed sine waves to square waves and the differentiation networks produce spikes determined by the slope of the sides of the square waves. Only the negative spikes trigger the flip-flop circuit. Signals above the threshold operating point of the two-stage limiters do not increase the amplitude of the square waves produced. Therefore, the phase indication obtained is independent of the amplitude relationship of the two signals being compared for phase.

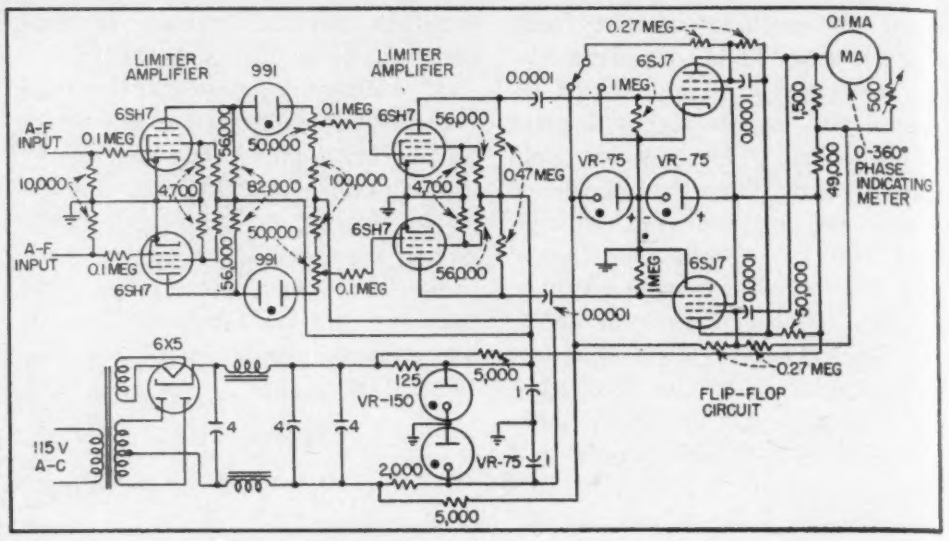
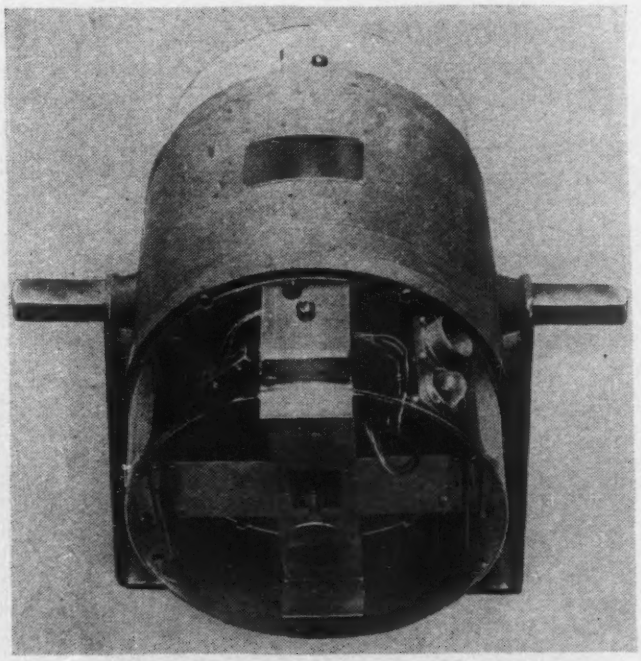
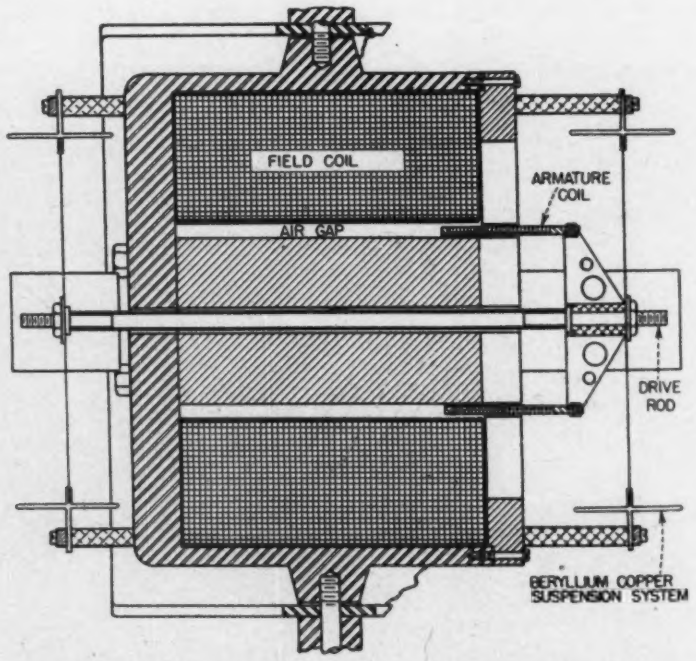


FIG. 4—Circuit used to indicate phase relationship between two a-f voltages

For their many helpful suggestions in the design and application of the electronic vibration equipment, the author is indebted to Lt. Col. B. Smilg of the Aircraft Laboratory, Wright Field; K. R. Jackman and Merle Brady, Test Laboratory, Consolidated Vultee, San Diego, California; E. A. Gardner, Engineering Department, Northrop Aircraft, Hawthorne, California, and R. E. Rawlins, formerly of Engineering Department, Lockheed Aircraft, Burbank, California.



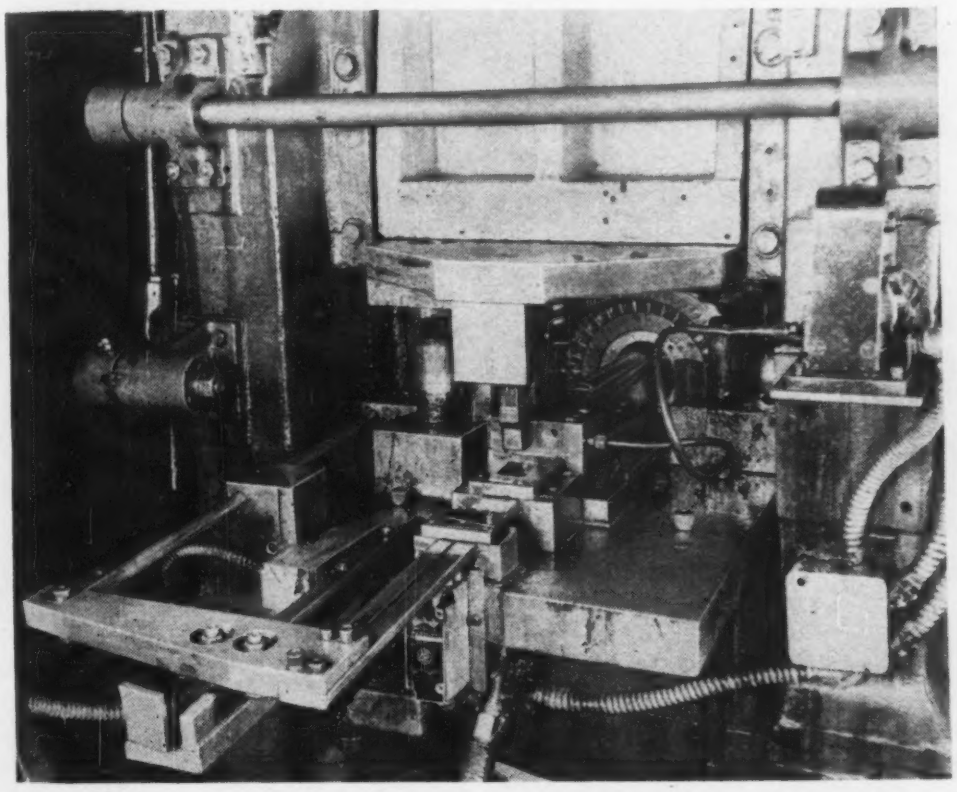
View of electromagnetic shaker unit. Plastic end bell protects armature and suspension system

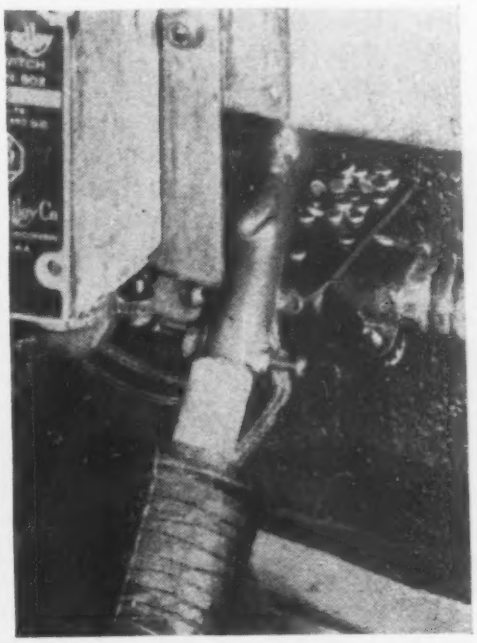


Cross-section of shaker. Armature is 4½ inches in diameter. Field coil uses 100 lb of copper wire

Punch Press Protector

When the slugs formed by a punch press are not cleared within three seconds, an electronic timer shuts off power. In normal operation slugs evacuated through a sensing unit prevent the timer starting





The die, compressed-air line, slug exit tube and sensing coil are shown in relation to the rear of the punch press. The detail above is the sensing coil that detects the passage of slugs

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IN MANUFACTURING cylindrical steel cases for a special application it is necessary to punch a number of holes all around the sidewall. This is accomplished by clamping each case in an automatic indexing fixture that is installed in a regular punch press. Each stroke of the press punches out 16 holes in the side of the case. The fixture is then automatically indexed and the operation repeated. This continues until the case has made one complete revolution. The small round slugs that are punched out fall into the hollow die and are blown out with compressed air.

In manufacturing the cylinders it soon became apparent that a problem existed in eliminating the small steel slugs from the hollow die once they had been punched out. The exit hole in the die was of necessity rather small and the slugs, instead of ejecting when the compressed air was turned on, tended to jam in the die. After about seven strokes of the press, the die would be completely filled and then the punches or the die or both would be damaged. This failure resulted in needless lost time and repairs. Also, though on less frequent occasions, the compressed air supply failed, resulting in damage to the equipment. The solution depended, then, on devising some means of

stopping the punch press in the event that the slugs were not properly ejected for any reason.

Variable-Inductance Sensor

First of all some sort of sensing unit had to be devised that would respond to the presence of the slugs as they were being ejected. It was also advisable that this sensing unit be sensitive to the number of slugs present. This ability was necessary since it was discovered that occasionally a few pieces stuck in the die after each stroke of the press and slowly built up an obstruction.

It was decided to make use of the magnetic properties of the slugs, whereupon the coil and funnel arrangement in Fig. 1 was devised. This unit was attached to the press in such a manner that slugs pass into the funnel and through the coil as they are ejected from the die. Another coil, identical with the first, was mounted about 6 inches from the press near the first coil. These coils, marked L_1 and L_2 in the wiring diagram of Fig. 2 form the two reactance arms of a simple bridge circuit. A fixed resistance and a series fixed and variable resistance combination make up the other two arms of the bridge. The variable resistance in one arm is used to balance the bridge circuit. Now, with the primary

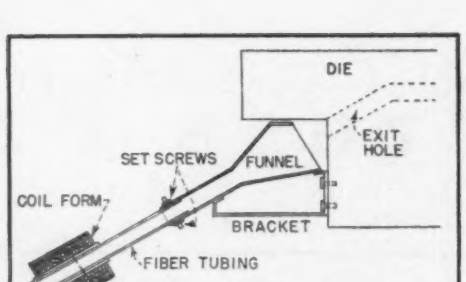

FIG. 1—Diagram of the die exit hole, funnel, and sensing coil mounted on fiber tube. Punchings are blown through this channel

of transformer T_1 energized and the bridge balanced, the presence of steel in the sensing coil causes a change in the inductance of this coil and so unbalances the bridge. This unbalance voltage appears across the primary of transformer T_2.

The coil and bridge arrangement satisfied the original requirement that the presence of the slugs be detected. However, the output of the bridge circuit at maximum unbalance was still rather small so it was necessary to amplify this voltage. It was done by the use of a conventional two stage amplifier using a 6SJ7, pentode connected, and a 6C5. Since this amplifier must amplify the line frequency (50 cycles), 0.1 microfarad coupling capacitors have been used and the plate circuit of each tube is by-passed to ground to prevent any high frequency feedback or regeneration that might be introduced. A test jack is provided in the plate circuit of the 6C5 so that an a-c voltmeter can be inserted when it is desired to balance the bridge.

Since compressed air is used to blow the metal slugs from the die, they pass through the sensing coil at a relatively high velocity. The bridge is only unbalanced for a fraction of a second so that an ordinary relay can not be made to operate satisfactorily on the amplified voltage. The relay is therefore connected in the plate circuit of a 2051 gas tetrode. In this type of tube when the plate is positive the tube will fire once the negative grid voltage is reduced to a critical value. When the tube fires the gas ionizes and the grid no longer has any control over the flow of plate current. Thus the amplified signal from T_3 is applied to the grid circuit of the 2051. When the instantaneous grid potential is reduced to the critical value the tube fires and relay K_1 is energized. Switch MS_2 is opened by the punch-press cycle and the unit is again ready to detect the presence of the metal slugs in the sensing coil.

It is necessary that the press be shut down if the die is not cleared after about three strokes. This is

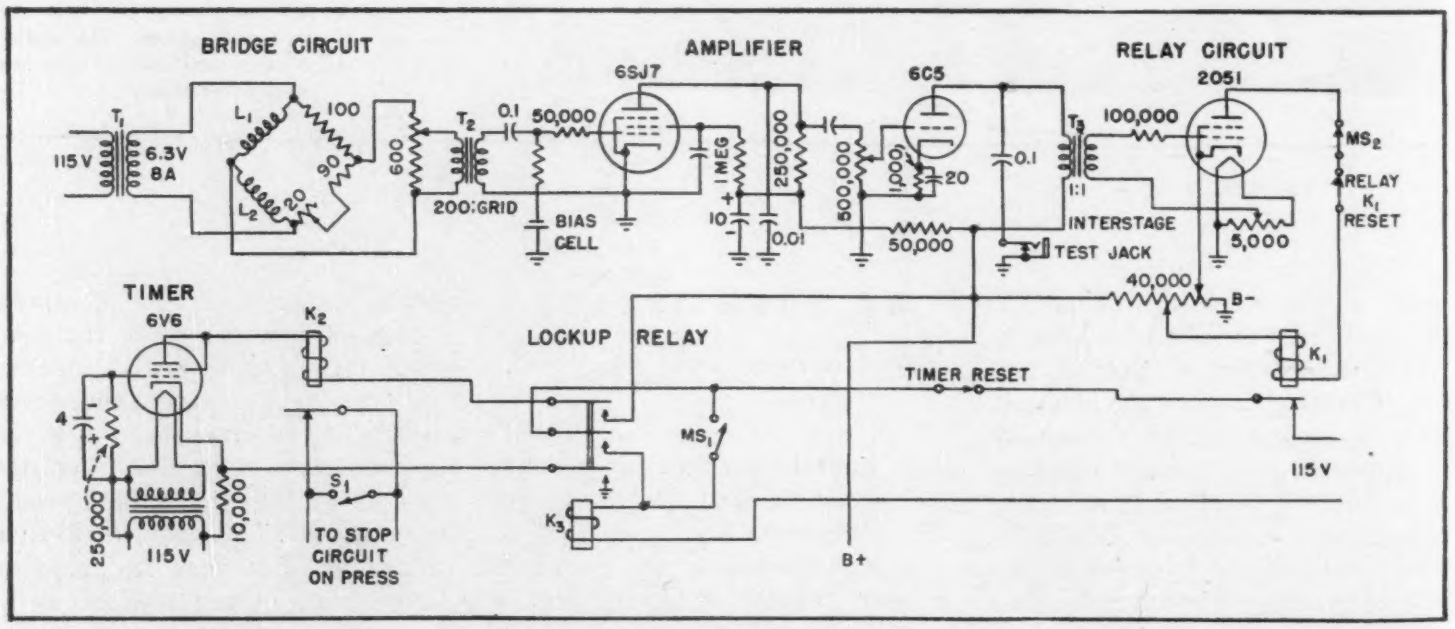

FIG. 2—Simplified schematic wiring diagram of the press-stopping circuit. Power supply, fuses, and no-voltage protection elements have been omitted for clarity

accomplished by the use of an electronic timer. The time delay is set for about 4 seconds (three strokes of the press) determined by the 4-microfarad capacitor and the 250,000-ohm resistor. When the plate and cathode circuits of the type 6V6 tube are disconnected through relay K_3 the cathode is connected to the hot side of the 115-volt line through the 10,000-ohm resistor. The capacitor and resistor combination connect from the control grid to the ground side of the line. The capacitor now charges because the grid and cathode constitute a half-wave rectifier. The charge leaves the grid negative with respect to ground. When relay K_3 is energized the plate and cathode circuits are connected normally. No current flows through K_3 in the plate circuit of the 6V6 tube because of the negative voltage on the grid. The 250,000-ohm resistor discharges the capacitor so that the grid bias is decreased and plate current rises sufficiently to cause the relay to pull in. This relay remains energized until the plate and cathode circuits are again broken.

Sequence of Operations

Now that the various components of the press protector have been described, their operation as a whole can be considered. The cycle of the punch press begins with the punch at the top of its stroke and the steel cylinder clamped in position over the die. As the punch starts down, a switch operates the solenoid valve that controls the flow of compressed air into the die. This blast blows out the steel slugs left in the die from the previous cycle. The slugs pass through the sensing coil, and cause relay K_1 to become energized.

As the punch reaches the bottom of the stroke the compressed air is turned off. At the same time, MS_1 is closed momentarily. A contact on relay K_1 in series with this switch completes the circuit through the coil of relay K_3 unless the contacts of K_1 are opened by the action of the emerging slugs. If relay K_3 operates it will close the plate and cathode circuits of the electronic timer that will then start through its cycle. In other words, as long as the slugs are ejected from the die, relay K_1 will become energized and prevent the timer from starting. In the event that relay K_1 does not become energized during three strokes of the press, the timer will complete its cycle and operate K_2, opening the contacts that stop the press.

As the punch reaches the top of its stroke switch MS_2 is actuated, causing the plate circuit of the 2051 to be broken. This mechanical operation is necessary because once plate current starts to flow the grid loses control and relay K_1 remains continuously energized.

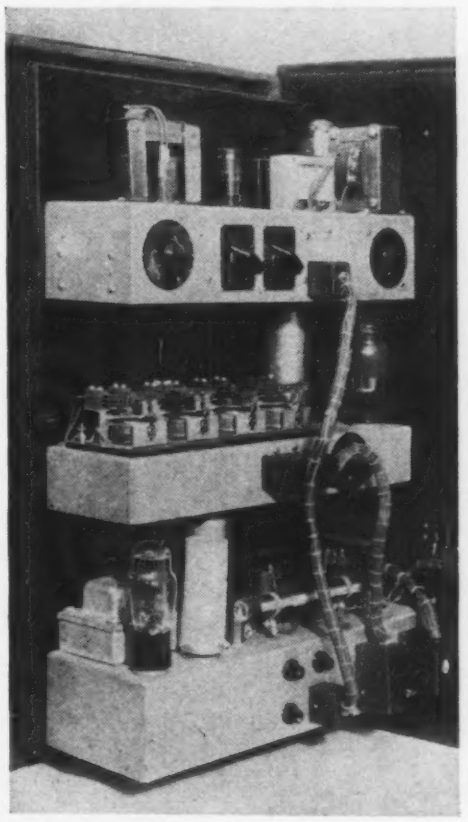

FIG. 3—Complete control unit is mounted in a cabinet on a hinged panel. The three replaceable chassis from top to bottom include: bridge circuit and amplifier, control sequence relays and timer, and power supply

Functionally, although it sounds complex, the entire unit is actually made up of only two basic parts; the amplifier that actuates a relay each time the steel slugs pass through the coil; and the electronic timer that is reset each time the relay is actuated. Such a system is adaptable to a number of similar applications and in some instances a simple snap-action switch can be the detecting or sensing device. This method could be used when relatively large articles were being turned out by a high-speed punch press or similar machine.

Practical Arrangement of Equipment

The mechanical construction of any piece of electronic equipment must receive prime consideration if it is to be used in an industrial plant. There is usually severe vibration in the vicinity of heavy machinery, especially a punch press of any size. This motion usually takes the form of sudden jolts.

Attaching the equipment directly to the machinery should be avoided if vibrations will affect its performance or reliability. The assembly of the press protector is shown in Fig. 3. From bottom to top, the power supply is mounted on the first chassis, the relays and the timer on the second, and the amplifier on the third. These chassis are mounted on a front panel that swings outward from the cabinet which houses the entire unit for ease in servicing and making adjustments. The chassis are connected together with cables and plugs. Any one of the three chassis can be quickly and easily replaced if it becomes defective. A cable that plugs into the power supply chassis is wired to a terminal board attached to the inside of the cabinet. The entire unit can thus be removed without disturbing the electrical connections to the terminal board. All electrical circuits are of course properly fused. A relay (not shown in Fig. 2) is connected so that if the power to the unit is disconnected or a fuse blows, the press is immediately shut off. A switch (S_1) is also provided so that when it is closed the press protector has no effect on the operation of the press. This is necessary so that the die setters can make adjustments on the press without having it shut off because no steel slugs are being ejected.

CASCADE PHASE SHIFT M

Simple new modulator circuit for f-m transmitters is easy to adjust and maintain, requires only standard tubes, and has minimum inherent amplitude modulation. Adding phase shifts of six crystal frequency stages permits low order of frequency multiplication

By M. MARKS

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IT is fairly evident that the direct crystal control which is characteristic of phase modulators offers a more reliable and straightforward circuit than systems using center-frequency correction, especially with the aid of a new simple phase modulator which has the necessary low distortion and low noise level.

The development of such a new modulator, closely approaching the ideal, has resulted from an exhaustive theoretical and experimental investigation of a large variety of phase shift modulators. This new modulator, known as the cascade phase shift modulator, allows the use of a relatively low order of frequency multiplication by adding the phase shift of a number of stages operating at the crystal frequency. The basic phase shift circuit accomplishes the task of modulation with a minimum of inherent amplitude modulation. Figure 1 is a simplified block diagram of the complete system.

Characteristics of Phase Shift Modulators

This paper will give a brief general review of phase shift modulators, showing the relationship between phase and frequency modulation, then develop the theory of the new modulator and give performance data.

When the phase of a carrier wave of constant frequency is advanced or retarded, the instantaneous frequency of the carrier also changes; the frequency deviation is proportional to the rate of change of phase.[1] The operation of all phase modulators depends on this important relationship, which may be visualized by considering a sinusoidal voltage of constant frequency. If the phase of this wave is advanced, say by 90 degrees, through insertion of a suitable phase shifting device, it can be seen that during the time taken for the phase to change to the new advanced value, the wave actually has to move faster than it would have moved if no change had taken place. Therefore, while the phase is changing, the effect is the same as if the frequency were higher. In a like manner, delaying the phase results in a lower frequency while the change is taking place. As soon as the shift in phase is stopped, the wave continues on at the original frequency.

From this, it follows that the more rapidly the phase is shifted, the greater will be the resulting frequency deviation. Thus, if the phase of an r-f signal is shifted by plus and minus 90 degrees at a sinusoidal audio-frequency rate of 100 cycles, the frequency would deviate (in accord with a cosine

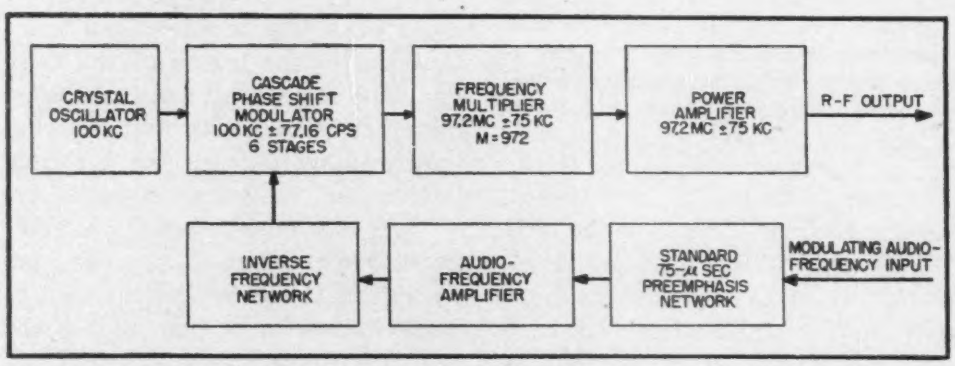

CRYSTAL OSCILLATOR 100 KC
CASCADE PHASE SHIFT MODULATOR 100 KC ± 77.16 CPS 6 STAGES
FREQUENCY MULTIPLIER 97.2 MC ±75 KC M=972
POWER AMPLIFIER 97.2 MC ±75 KC
R-F OUTPUT
INVERSE FREQUENCY NETWORK
AUDIO-FREQUENCY AMPLIFIER
STANDARD 75-μ SEC PREEMPHASIS NETWORK
MODULATING AUDIO-FREQUENCY INPUT

FIG. 1—Block diagram of f-m transmitter using cascade phase shift modulator

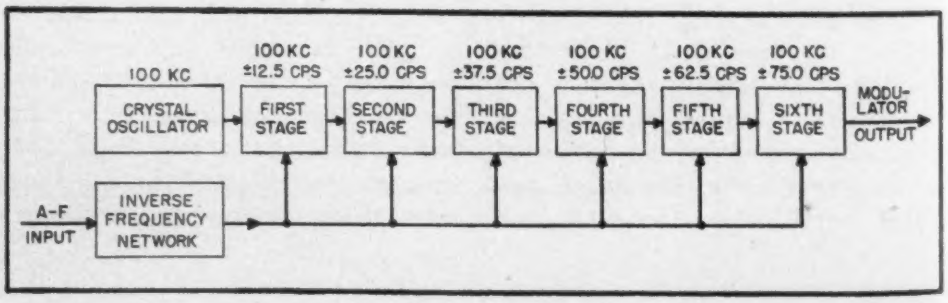
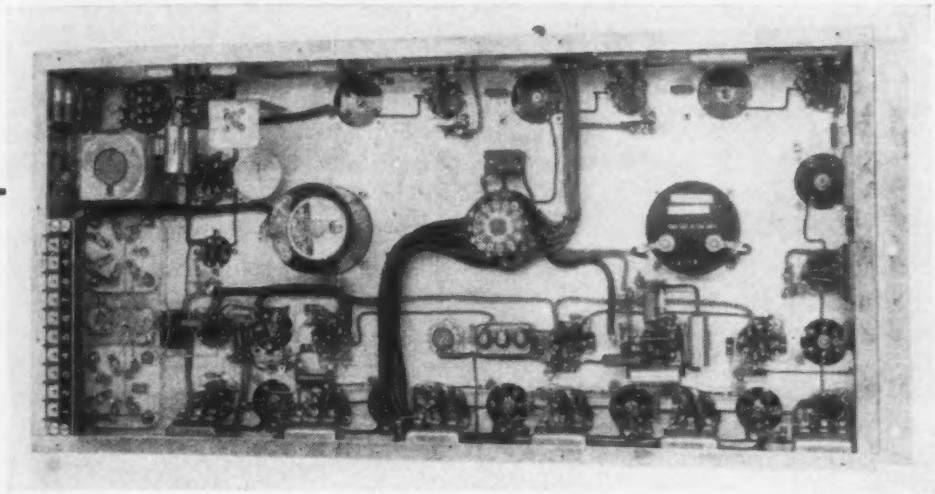
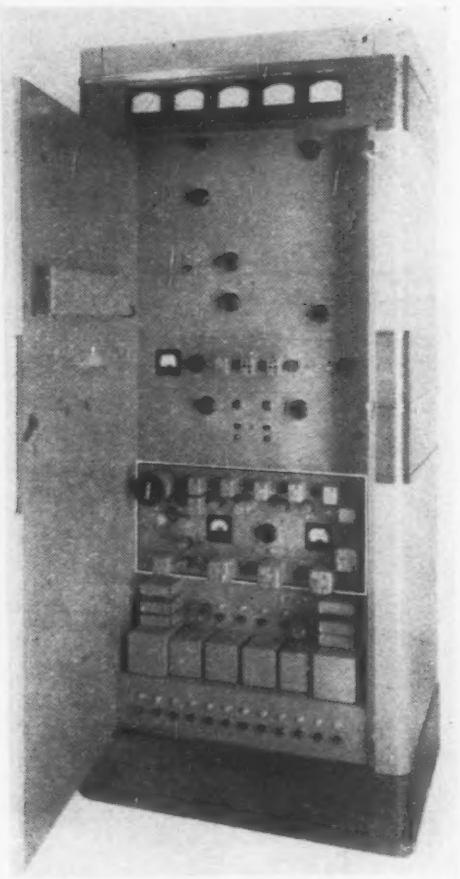


FIG. 2—Block diagram showing individual stages of cascade phase shift modulator. A maximum phase shift per stage of plus or minus 23.9 degrees is required for a 30-cycle signal at full frequency deviation

MODULATOR



Back view of cascade phase shift modulator for 250-watt f-m transmitter



Cascade phase shift modulator (second panel from bottom, outlined) installed in 250-watt f-m broadcast transmitter

function) 157 cycles above and below the original frequency; if the audio frequency rate of phase shift is now increased tenfold to 1,000 cycles, the frequency deviation will likewise be increased ten times to give 1,570 cycles deviation. The frequency deviation in cycles, therefore, can be seen to equal the product of the audio frequency (also in cycles) and the phase shift in degrees, divided by a constant (the number of degrees per radian).

Inverse Frequency Network

Inasmuch as the frequency deviation must be held constant at 75,000 cycles for 100-percent modulation, regardless of the modulating frequency, the number of degrees phase shift must be varied inversely with the modulating audio frequency. This effect is readily accomplished by use of an integrating circuit (also known as an inverse frequency network), consisting of a series resistance and a shunt capacitance, usually placed between the source of modulating signal and the phase modulator. The higher modulation frequencies are thus attenuated in precisely the desired manner for true frequency modulation.

The phase shift obtainable with low distortion from conventional phase modulator circuits rarely exceeds 25 degrees. The resulting frequency deviation for a 30-cycle modulating signal may be readily calculated to be equal to 13.1 cycles. Since this small deviation falls far short of the required 75,000 cycles, it becomes necessary to multiply the original frequency deviation by a factor M approximately equal to 6,000 in order to attain the required final frequency deviation. The well-known fact that multiplication of frequency produces a like multiplication of frequency deviation is used for this purpose to good advantage in practically all phase modulators.

There is a good practical reason, however, for keeping M not much over 1,000. Assuming the lowest usable crystal frequency as 75 kc (5 times the highest audio frequency) and an operating frequency of 100 mc, a factor M equal to 1,333 is obtained. To attain higher multiplication factors than this, it is necessary to resort to the use of heterodyne frequency converters.

Frequency Converters

In general, frequency converters are undesirable because the spurious beat frequencies present in their output circuits must be carefully discriminated against by means of tuned circuits and adequate shielding. In addition, there is the possible production of additional spurious beats caused by voltages from the low-frequency stages entering one or more of the broad pass bands of the stages following the converter. Hence, if M can be reduced to approximately 1,300 or less, the above difficulties will not materialize.

Addition of Phase Shifts

Large values of M are a direct consequence of the limited phase shift of which conventional modulators are capable. It is possible, however, to increase the useful phase shift of a modulator substantially by adding the individual phase shifts of two or more stages connected in cascade. The block diagram of Fig. 2 illustrates the manner of connecting the phase shift stages in cascade for the transfer of r-f energy, but in parallel as far as the a-f signal is concerned. The progressive increase of frequency deviation from stage to stage is also given for N, the number of cascaded stages, equal to

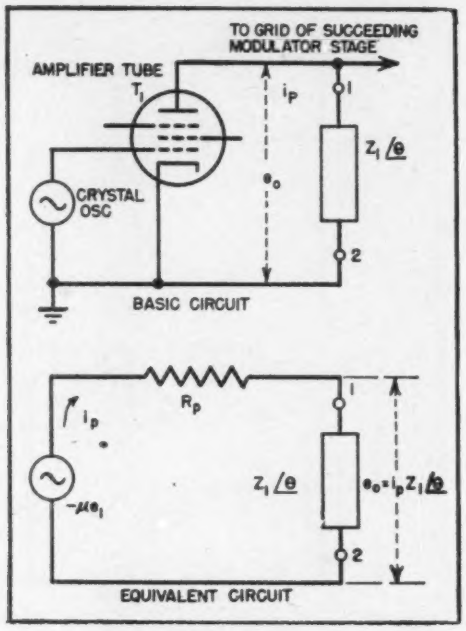


FIG. 3 (left)—Basic phase shift stage operating at crystal frequency, and equivalent circuit

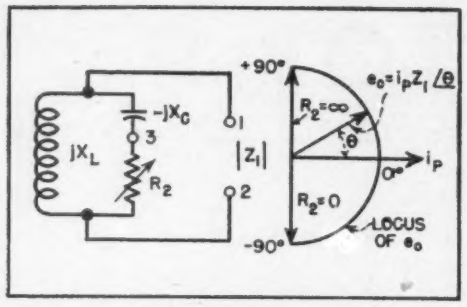


FIG. 4 (above)—Constant-impedance network and corresponding vector diagram

6, and for a maximum phase shift per stage of 23.9 degrees (required for a 30-cycle a-f signal at full deviation). It should be noted that if only the first stage were used ($N = 1$), the conventional modulator would result for which M must be 6,000 (75,000 cycles/12.5 cycles); if all six stages are used ($N = 6$), M is reduced to 1,000 (75,000 cycles/75 cycles)—the latter condition obviating the need for a frequency converter.

From the preceding discussion it follows that N may be considered as effective as M in producing the final frequency deviation. This relationship may be stated as follows: The frequency deviation at the operating frequency in cycles is equal to the product of the audio frequency in cycles, the phase shift per modulator stage in degrees, the factor M, and the factor N, divided by the number of degrees per radian (57.3).

There is yet another advantage which comes from keeping M relatively low. When an unmodulated r-f signal is passed through a vacuum tube amplifier, it becomes modulated by the random noise voltages which are ever present; one portion produces amplitude modulation of the r-f signal and the other produces irregular fluctuations in its phase.

The amplitude modulation is readily removed by the limiting action of subsequent multiplier stages, but the irregular fluctuations in the phase of the signal represent a noise modulation. The frequency deviation corresponding to these fluctuations increases for the higher audio frequencies because there is no inverse frequency network to attenuate them. The magnitude of the resulting phase shift of the r-f wave due to the noise may be shown[3] to be approximately equal to 57.3 times the value of noise voltage divided by the signal voltage. Hence, assuming a noise of 10 microvolts and a signal of 10 volts, the phase shift would be approximately 0.0000573 degrees.

For $N = 1$ and $M = 6{,}000$, approximately 0.05 degree phase shift is required at 15,000 cycles to produce 100 percent modulation. The ratio, then, of the phase shift for 100 percent modulation to the noise phase shift, expressed in db, should give the f-m noise level at the output frequency. For the above case ($M = 6{,}000$) the noise level is 58.8 db below 100 percent modulation. Performing the same calculation for $M = 1{,}000$ and $N = 1$, the phase shift required is 0.3 degree, and the noise level for this source of noise becomes 74.4 db below 100 percent modulation.

Cascading of Stages

The foregoing calculations considered the case of an unmodulated r-f signal for $N = 1$. The effect on the noise level of adding N modulator stages in cascade will now be taken up. As previously mentioned, the phase shift appearing at the modulator output terminals is equal to the sum of the phase shifts produced in the individual stages. But the random nature of fluctuation noise produced in each modulator stage makes it necessary to take the rms sum of these voltages in order to find the resultant noise voltage at the modulator output terminals. Therefore, N modulator stages will add $\sqrt{N}$ times the noise of one stage. If four stages are cascaded, there will be a fourfold increase in phase shift, but only a twofold increase in the noise of the system. In actual practice, noise is also produced in other parts of the transmitter, so that the relative contribution of the modulator section to the total noise is even smaller.

In order to minimize harmonic distortion under certain conditions of modulation, it is desirable to use a modulator circuit in which the percentage of amplitude modulation produced concurrently with phase modulation is very small. This distortion becomes a maximum when the percentage of phase modulation is such as to produce only the first pair of sidebands.[4] The effect in this case consists of a change in the relative magnitudes of the sideband, and any subsequent limiting action which may remove the amplitude variation will still be powerless to restore the relationship between the carrier and sidebands necessary for low distortion. Therefore, a further requirement for the design of the modulator is that any amplitude modulation produced along with the desired phase modulation be kept at a minimum.

Theory of Cascade Phase Shift Modulator

The basic phase shift stage in Fig. 3 consists of an amplifier tube T_1 and its plate load impedance, the two-terminal network Z_1 connected across terminals *1* and *2*.[4] T_1 serves both as an amplifier which isolates the cascaded phase shift stages from one another and as a source of constant current for Z_1.

From the equivalent circuit it follows that the phase of the output

voltage e_o must vary as the phase angle of Z_1. This is so because the load impedance is much smaller than the plate resistance R_p and therefore can have practically no part in determining the plate current i_p. Since the product of the plate current and the vector impedance, $Z_1 \angle\theta$, is equal to the output voltage, any change in phase of this impedance must therefore result in phase modulation of the output voltage. It also follows that any change in the magnitude of Z_1 will result in amplitude modulation of the output voltage.

The two-terminal network shown in Fig. 4 may be designed to maintain a substantially constant impedance while phase modulation is taking place. The general expression for the impedance of this network is[6]

$$|Z_1| = X_L \sqrt{\frac{1 + \left(\frac{1}{b}\right)^2}{1 + \left(\frac{1}{b}\right)^2 \left(\frac{1}{a} - 1\right)^2}} \qquad (1)$$

where

$$a = X_C / X_L \qquad (2)$$

$$b = R_2 / X_C \qquad (3)$$

A study of Eq. 1 will show that when the quantity $(1/a) - 1$ is set equal to unity, the quantity under the radical sign will also be equal to unity and therefore $|Z_1|$ will remain constant and equal to X_L regardless of any variation of b. This condition occurs when a is set equal to 0.5. Substituting this solution in Eq. 2, it follows that $|Z_1|$ will be constant when

$$X_L = 2X_C \qquad (4)$$

This network is used as the plate load of a vacuum tube whose plate resistance is over 100 times greater than $|Z_1|$, and since the parallel resistance of a coil with a Q of about 30 is also of the same high order of resistance, the effect of these two quantities on the magnitude of Z_1 may be neglected. These two quantities, however, do play a minor part in determining the phase angle of the network. Therefore, the phase characteristic of the network[6], calculated for a coil Q of 30, is shown in Fig. 5 for values of a equal to 0.4, 0.5 (the constant-impedance solution), and 0.6.

A mental picture of the phase shift action to which the output voltage in this circuit is subjected may be obtained by considering the two extremes of resistance, bearing in mind that the inductive reactance is equal to twice the capacitive reactance (Eq. 4). For R_2 open, the current through terminals *1* and *2* of Fig. 4 must be inductive. Therefore, the output voltage will lead the plate current by approximately 90 degrees.

When R_2 is short-circuited, the current taken by the capacitive branch will be twice as great as that taken by the inductive branch, thus making the net current into terminals *1* and *2* capacitive. The output voltage, therefore, will lag behind the plate current by approximately 90 degrees for this other extreme. Intermediate values of R_2 will cause the locus of the output voltage vector to follow the semicircle depicted in Fig. 4.

The most important part of the basic shift stage is the device which converts the a-f modulating signal into a corresponding a-f variation of resistance. This device, which is known as the modulator or resistance tube, replaces R_2 of Fig. 4 in the practical circuit. To obtain low distortion, the characteristic of resistance versus control voltage of this device must be made to approximate the curvature of the phase angle characteristic (Fig. 5). This requirement is important mainly for low-frequency signals in the band from 30 to 50 cycles, where a maximum phase shift of about plus and minus 25 degrees per stage is required for full frequency deviation.

Conventional vacuum tube circuits utilizing the dynamic plate resistance of a tube as a function of control grid voltage cannot be used because the adjustment of bias becomes too critical when the above requirement must be met. Therefore, the circuit shown in Fig. 6 was developed to do the job. With the r-f voltage assumed to be zero, the circuit behaves not unlike a cathode follower. The plate is bypassed to ground through C_2, the a-f modulating signal e_i is applied between control grid and ground (across the shunt capacitance C_1 of the inverse frequency network), and an output voltage (the gain is less than one) appears between cathode and ground. For this condition of operation the resistance looking into terminals *2* and *3* may be given as[7]

$$R = \frac{1}{\frac{1}{R_k} + \frac{1}{R_p} + \frac{\mu}{R_p}} \qquad (5)$$

where R_k is the resistance connected externally between cathode and ground, R_p is the effective plate resistance of the tube at its oper-

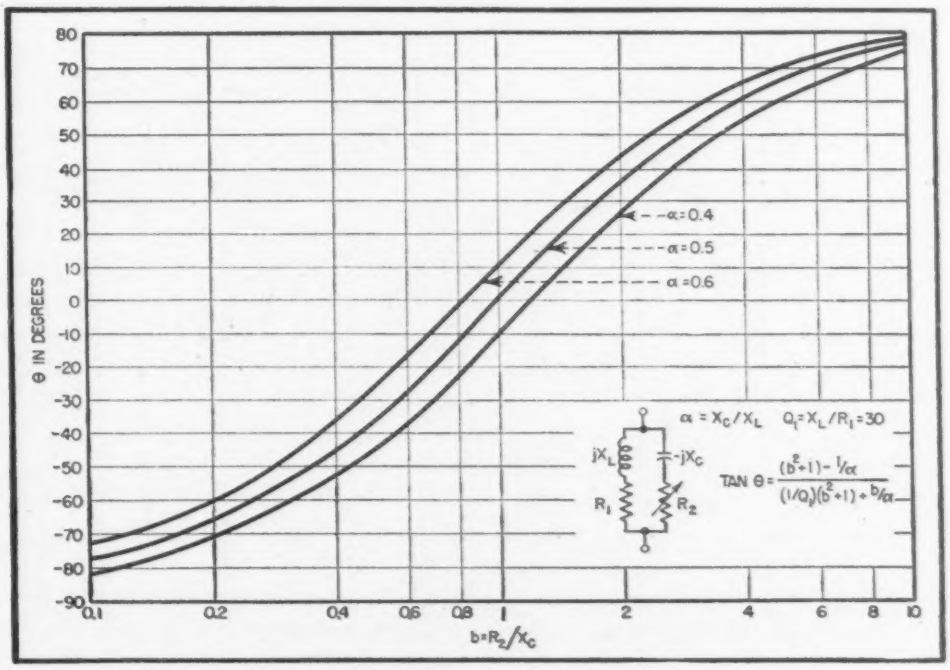


FIG. 5—Phase characteristics of constant-impedance network

ating point, and μ is the amplification factor of the tube at its operating point.

Analysis of R-F Cycle

Now consider the circuit from the standpoint of the r-f voltage e_o, which is the voltage across the constant impedance Z_1 in Fig. 3. Assuming the modulating signal e_s in Fig. 6 equal to zero, the circuit behaves like a grounded grid amplifier because C_1 effectively puts the grid at ground potential for r-f. Thus, any r-f voltage between cathode and ground is also applied between control grid and cathode of T_2. Under normal conditions of operation, the relatively high value of R_k never allows grid current to flow during the positive portion of the r-f cycle. However, if the r-f grid-to-cathode voltage is high enough, tube T_2 will be cut off during some part of the cycle, the point of cutoff being a definite function of the instantaneous grid-to-cathode and plate-to-cathode voltages.

The modulating a-f signal e_s thus determines the fraction of the r-f

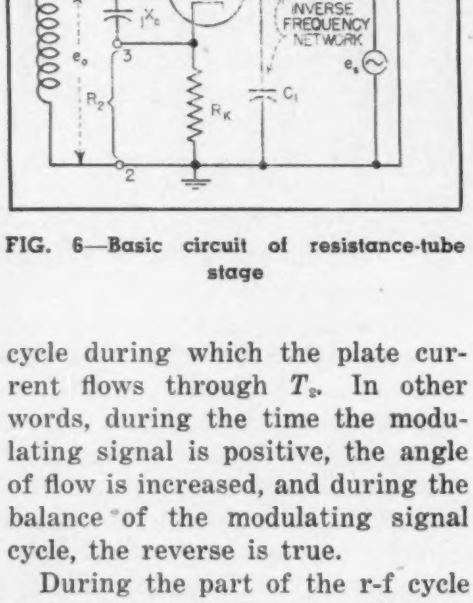


FIG. 6—Basic circuit of resistance-tube stage

cycle during which the plate current flows through T_2. In other words, during the time the modulating signal is positive, the angle of flow is increased, and during the balance of the modulating signal cycle, the reverse is true.

During the part of the r-f cycle cycle over which T_2 is cut off, R_2 is equal to R_k. For the remainder of the r-f cycle, R_2 must be equal to R as defined by Eq. 5. By proper choice of r-f voltage level and the value of R_k, the curvature of the resistance tube characteristic can be made to match the curve in Fig. 5, so that no bias adjustment is necessary.

Modulator Tuning Procedure

In the final design of the modulator portion of an f-m transmitter using the cascade phase shift modulator, six cascade stages are followed by several frequency multipliers with a factor M of 12, as shown in Fig. 7. The final multiplier provides an M equal to 81, so that the overall M is 972. A built-in tuning meter enables the operator to make adjustments without the aid of external measuring equipment.

Assuming that the crystal oscillator stage is operating normally, the r-f voltage level at the grid of each cascade amplifier (T_3 through T_9) is adjusted to a predetermined setting on the tuning microammeter. Although this meter reads the grid current, it acts as a peak-reading vacuum-tube voltmeter. A variable capacitor in each amplifier grid circuit provides the means of adjustment by forming a simple voltage divider with the associated coupling capacitor. This r-f voltage

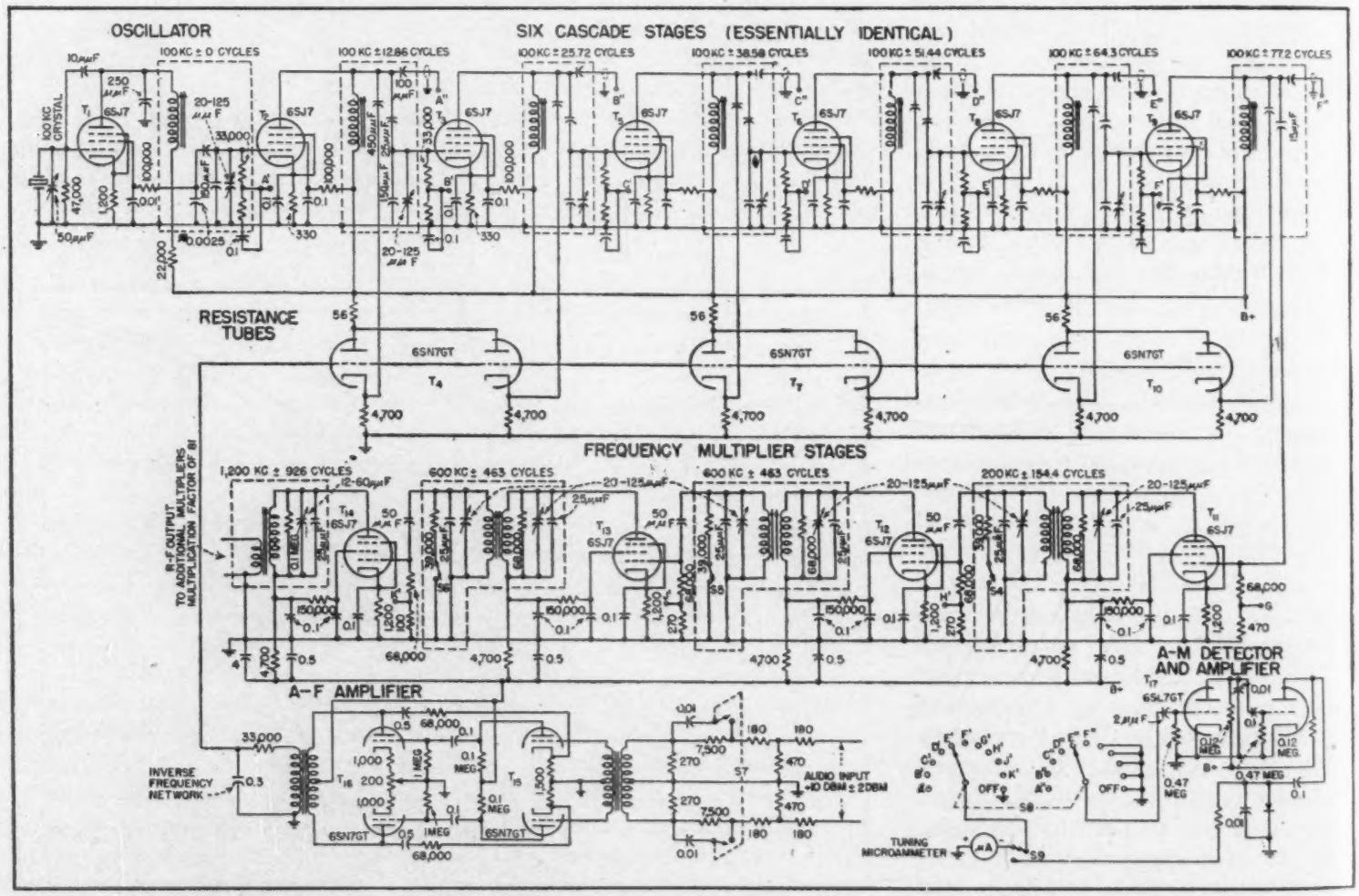

OSCILLATOR
SIX CASCADE STAGES (ESSENTIALLY IDENTICAL)
100 KC CRYSTAL
100 KC ± 0 CYCLES
100 KC ± 12.86 CYCLES
100 KC ± 25.72 CYCLES
100 KC ± 38.58 CYCLES
100 KC ± 51.44 CYCLES
100 KC ± 64.3 CYCLES
100 KC ± 77.2 CYCLES
RESISTANCE TUBES
6SN7GT
FREQUENCY MULTIPLIER STAGES
1,200 KC ± 926 CYCLES
600 KC ± 463 CYCLES
200 KC ± 154.4 CYCLES
R-F OUTPUT TO ADDITIONAL MULTIPLIERS MULTIPLICATION FACTOR OF 81
A-F AMPLIFIER
INVERSE FREQUENCY NETWORK
AUDIO INPUT +10 DBM ± 2DBM
A-M DETECTOR AND AMPLIFIER
TUNING MICROAMMETER
OFF

FIG. 7—Schematic diagram of modulator of f-m transmitter using the cascade phase shift modulator

level setting fulfills the requirement for curve matching of the resistance tubes.

For the next step, the inductance X_L of the constant-impedance network in each amplifier must be adjusted to conform with Eq. 4. Ordinarily this would present a difficult problem because the coil cannot be peaked to the crystal frequency—the actual resonant frequency being the crystal frequency divided by 1.414. However, this difficulty may be overcome by taking advantage of the theory which states that a minimum of amplitude modulation will be observed at the plate of each amplifier tube when the inductance of its constant impedance network is adjusted correctly (X_L equal to $2X_C$).

Accordingly, an a-f modulating signal is applied through the normal a-f channel, of a level sufficient to bring about full frequency deviation and of a frequency low enough to produce a reasonably large phase shift in each modulator stage. Then use is made of a built-in amplitude modulation detector and amplifier (the double triode T_{11}) which uses the microammeter as a modulation indicator. Sample r-f voltages from each phase shift amplifier plate are piped over to this detector via the meter switch, and thus any plate may be selected at will.

Starting with the first stage, each inductance in turn is adjusted for minimum meter deflection of the amplitude modulation indicator. Of course, if the coils are found to be so far out of adjustment as to materially alter the r-f voltage set up in the initial step, then both steps must be repeated. That is all there is to the adjustment of the modulator proper.

Transmitter Alignment

The only other adjustments are those of the multiplier and amplifier coupling transformers. These transformers are designed so they will pass a band wide enough to accommodate twice the highest modulating frequency, but attenuate the undesired adjacent harmonics produced in the preceding stages. These requirements usually lead to a slightly double-peaked selectivity curve corresponding to a coupling greater than critical.

Misalignment of such transformers invariably causes asymmetrical selectivity curves, which usually increase the harmonic distortion and may even reduce the frequency deviation for the higher modulating frequencies. It is important, therefore, that overcoupled transformers be properly aligned.

The method of alignment of overcoupled transformers adopted for use in this transmitter is simple, requires no external equipment and gives the right answers in terms of performance. A pushbutton switch is provided on all overcoupled transformers. A damping resistance is permanently connected to the top of the secondary of each transformer, and when the pushbutton switch is pressed, the free end of the damping resistance is grounded. This action has the effect of decreasing the secondary impedance. Because the ground side of the resistance is switched, there is no appreciable change of circuit capacitance due to the switching action.

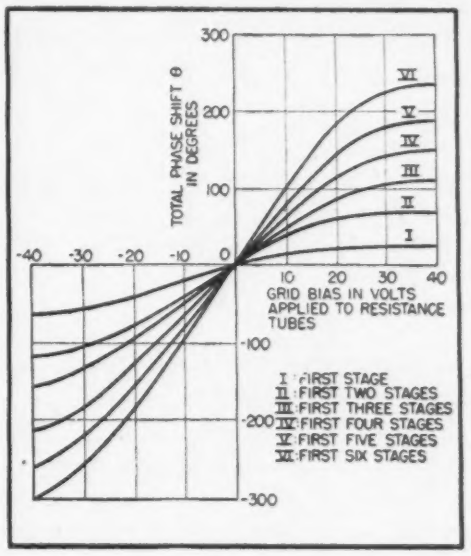


FIG. 8—Operating characteristics of cascade phase shift modulator

It is well known that a decrease of secondary impedance in an overcoupled transformer reduces the coupling. Thus, with proper choice of damping resistance, the coupling is reduced to a value below critical and the transformer may be easily and accurately tuned for maximum output at the center frequency provided by the preceding stage.

Upon releasing the pushbutton, the transformer again becomes overcoupled and gives the symmetrical pass band required for high-quality performance. All band-pass transformers are aligned in this manner. Normal transmitter tuning technique is used for the higher-powered portions of the transmitter. It is possible to adjust all tuning elements shown in Fig. 7 in less than ten minutes.

Performance of Cascade Phase Shift Modulator

A static characteristic curve giving the total phase shift in degrees as a function of the grid bias applied to the resistance tubes for 1, 2, 3, 4, 5, and 6 cascade stages is shown in Fig. 8. The linearity of the curve for six stages is attested by harmonic distortion measurements, for 75-kc frequency deviation, of 1.25 percent for 30 cycles and less than 0.6 percent for 50 to 15,000 cycles. Distortion for 100-kc frequency deviation is less than 1 percent from 50 to 15,000 cycles. The f-m noise has been measured at 72 db below a frequency deviation of 75 kc.

The author wishes to express his appreciation for the perseverance and help given by W. E. Phillips and S. G. Jones, under whose direction this modulator was developed, and to D. A. Skinrood, G. L. Dufield, L. Schultz, E. A. Andrade, and Y. K. Luk of the Broadcast Equipment Division of Raytheon Manufacturing Co.

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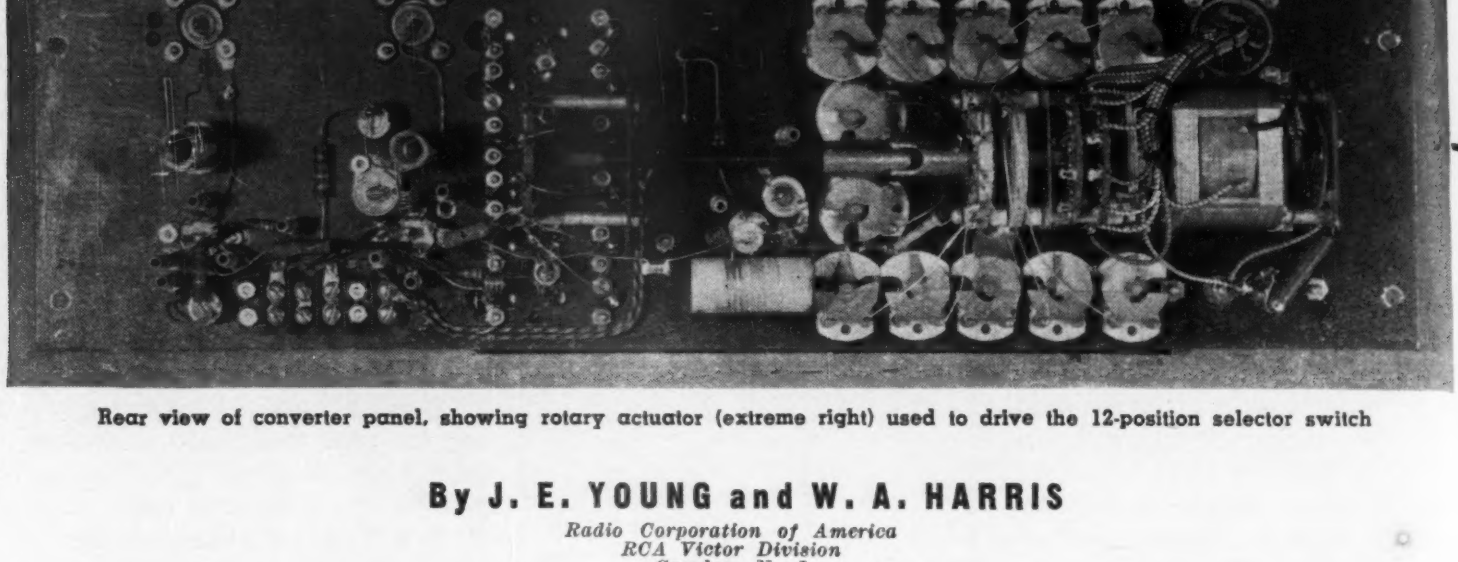
TWELVE-CHANNEL



Rear view of converter panel, showing rotary actuator (extreme right) used to drive the 12-position selector switch

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Camden, N. J.

THIS 12-channel converter was designed for use with a remotely-controlled prewar 42 to 50-mc f-m receiver to permit reception of stations in the new 88 to 108-mc f-m band.

Since there appeared to be no satisfactory method of rapidly setting a ganged capacitor with the accuracy required at 100 mc, 12 sets of fixed-tuned circuits were provided. These were well adapted to incorporation in the Strowger dial system used in remote operation of the original receiver. This system provides facilities for telephone-type dial selection from any one of twelve stations on each of the a-m, f-m, and television receivers, plus volume control, audio-bandwidth control, and loudspeaker selection.

The desirability of obtaining a satisfactory signal from broadcast stations over 75 miles away required that the sensitivity of the converter be of the order of a microvolt for 20-db quieting. In addition, the presence of other f-m stations within a few miles of the receiver and other services in adjacent frequency bands imposed severe requirements as to selectivity, stability, and spurious frequency response.

The complete converter circuit is shown in Fig. 1. The input circuit inductor of the r-f amplifier is tuned by a powdered iron slug in a relatively high impedance circuit which is broad-band enough to require no tuning adjustment to cover the 88 to 108-mc band. It was considered that any attempt to provide fixed tuned circuits at this point for each desired frequency would result in a circuit having such a low impedance and low antenna transformer stepup that the signal-to-noise ratio would be adversely affected. Coupling from the input transmission line was effected by tapping the line directly on the input inductor, thereby eliminating the effect of coupling coil inductance.

The 6AK5 tube was chosen because it possesses relatively high input resistance at the frequencies involved. This high input resistance, together with careful adjustment of the coupling ratio, permits obtaining an input circuit gain high enough so that it is possible to realize a sensitivity of 1.5 microvolt for 20 db of quieting at any frequency in the band.

To obtain good image rejection, the coupling circuit between the r-f amplifier and the mixer was designed to have high Q. By use of high values of capacitance, the impedance was kept low enough so that the gain of the 6AK5 tube was not sufficient to permit self-oscillation. The low circuit impedance makes it possible to use parallel feed to the plate of the 6AK5.

Mixer Circuit

To obtain a high image rejection ratio, it was necessary that the mixer input circuit be tuned. However, its tuning has little effect on the oscillator stability, so ceramic trimmer capacitors having a range of from 7 to 45 $\mu\mu$f were used to resonate the inductor and an 18-$\mu\mu$f fixed capacitor was connected in series with the switch arm. With this arrangement, the relatively large variable capacitors minimize the effects of switch and stray capacitances, while the series capacitor keeps the maximum total shunt circuit capacitance down to the desired value.

The coupling capacitor and its leads are so proportioned that in spite of necessarily long leads virtually the full a-c plate voltage developed by the 6AK5 tube is realized across the grid circuit of the 6AS6 mixer tube.

Oscillator injection is provided to one grid of the mixer tube. A coupling coil of the proper size to match a 50-ohm line to the mixer plate is used, since it was expected that the 42-mc receiver used as the i-f amplifier would be located too

F-M CONVERTER

Telephone-dial selection of any of twelve stations in new f-m band is achieved remotely with prewar f-m receiver by use of three-tube converter in which mixer input and oscillator are tuned by preset trimmers connected to 12-position rotary selector switch

far away to permit using a high-impedance coupling circuit. Coil L_5 lowers the frequency of a parasitic plate circuit sufficiently so that feedback conditions do not support oscillation.

Oscillator Circuit

The circuit chosen for the oscillator was one in which the plate is at r-f ground. To minimize the effect of alternating current on the heater and to eliminate trouble from variable heater-cathode capacitance, the heater is kept at the same r-f potential as the cathode. This was accomplished by connecting one side of the heater to the cathode, permitting the heater current to flow through the tank inductor and return through a choke. Tuning was effected by varying the capacitance from grid to ground.

The method of tuning made it necessary to use either a grounded plate or grounded grid oscillator. The former was selected because the anode acts as a tube shield, minimizing the effect of external objects on the oscillator frequency, and no plate feed choke is required.

The vernier adjustments for the oscillator tuning capacitors were constructed by tapping a hole in the panel adjacent to an individual tuning capacitor shaft and inserting a knurled-head screw to extend near the capacitor stator. Variation in the position of the shank shifts the frequency 100 to 200 kc.

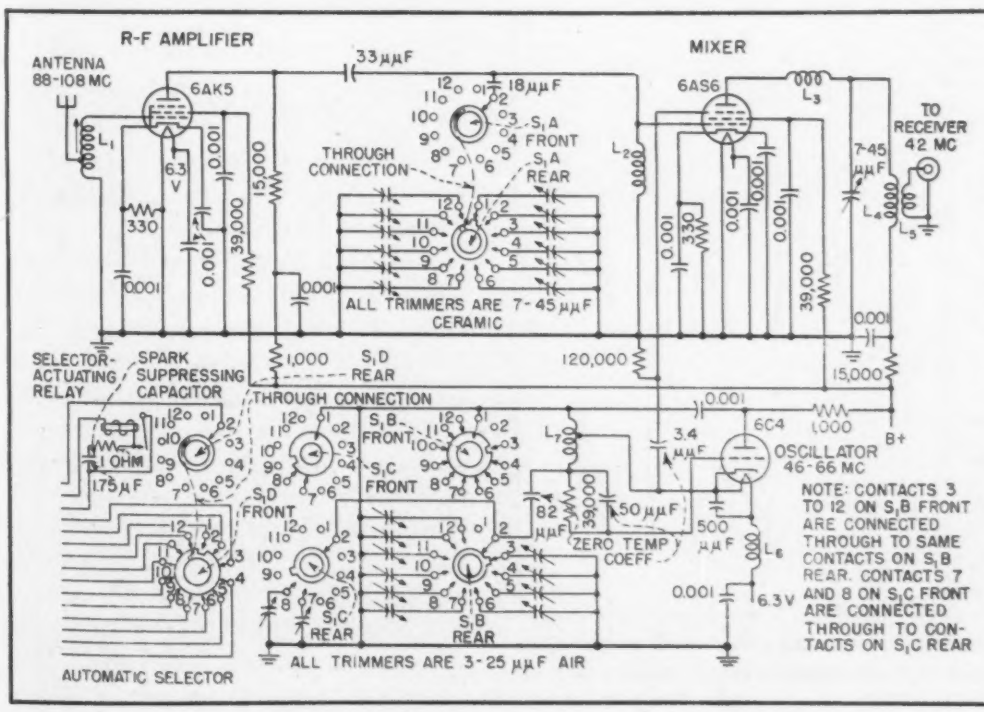
Mechanical Features

A rotary actuator (Price Electric Corp. type 8500 automatic selector) provides the means for driving the standard 12-position wafer switches used to select the proper tuned circuits in each stage.

Poor stability and resetting difficulties in early tests resulted because the shaft of the selector switch was insulated and electrically loaded by the switch mechanism to be near quarter-wave resonant at the oscillator frequency. It was necessary to ground the rubber-mounted switch frame with a flexible copper strap to break up the resonant circuit.

The selector switch actuator was designed to operate on a 24-volt d-c circuit, but after the proper capacitor-resistor combination for use across the contacts had been determined, satisfactory operation on 115 volts a-c was obtained.

Sensitivity is such that 20-db quieting is obtained with an input signal of less than 1.5 microvolts applied in series with a 70-ohm resistor, and spurious frequency response is more than 70 db below the wanted signal at any frequency except the 42-mc i-f image, where suppression is 50 db. Overall warmup drift of the system is almost the same as the warmup drift of the 42-mc receiver.



Coil Winding Data

L_1 — 5 turns No. 18, 7/16″ long on ½″ diam. polystyrene form, tapped 1¼ turns from ground end, with 3/8″ diam. by ½″ long carbonyl iron core

L_2 — 4 turns No. 16, 5/16″ long, 7/32″ diam. mandrel, self supporting

L_3 — 6 turns No. 20, 5/16″ long, 3/16″ diam. mandrel, self supporting

L_4 — 5 turns No. 22 dcc, 7/16″ long on ½″ diam. polystyrene form

L_5 — 2 turns No. 22 dcc, close wound 3/32″ from L_4

L_6 — 13 turns No. 18, spaced 1 wire diam. on ½″ diam. ceramic standoff insulator

L_7 — 3 turns No. 18, on 3/4″ diam. ceramic tube grooved 12 turns per inch, tapped 1 5/8 turns from plate end

FIG. 1—Complete circuit of converter. Leads at lower left go to remote control system

Wideband P

Design criteria are presented for L-C and R-C phase shifting networks that develop a constant phase difference over a wide frequency band. The technique is to introduce two phase shifts such that, although they vary with frequency, their difference does not

IT IS frequently desirable to derive from a given voltage two new voltages of the same frequency but with the phase angle between the new voltages held substantially constant over a wide frequency range, each derived voltage having an amplitude characteristic linearly variable with the amplitude of the input voltage independently of frequency.

To produce the phase difference between the two voltages, two networks whose phase angles increase substantially linearly with the logarithm of the frequency are used. Thus, if the two networks are properly matched, the phase difference between them remains nearly constant over a wide range of frequency.

Network Development

One way of producing the two voltages is to derive both of them from a single source and arrange that the output of either channel is independent of frequency, but that both have phase angles with respect to the input voltages varying in such a way that over a wide band of frequencies

$$\phi_1 - \phi_2 = K \qquad (1)$$

where ϕ_1 : phase angle of output No. 1
ϕ_2 : phase angle of output No. 2
K : a constant
ϕ_1 and ϕ_2 are each their own function of f, the frequency

One possible configuration for these functions is

$$\phi_1 = C + \log f \qquad (2)$$

$$\phi_2 = C + \log kf \qquad (3)$$

where C and k are constants

Substituting Eq. 2 and 3 in Eq. 1

$$\begin{aligned}\phi_1 - \phi_2 &= C + \log f - C - \log kf \\ &= \log f - \log f - \log k \\ &= -\log k \equiv K \end{aligned} \qquad (4)$$

Thus it is only necessary to find a network configuration which will yield a phase angle which varies as the logarithm of the frequency over a wide range of frequency. The network must also have no change in output amplitude with frequency. The latter limitation usually restricts the final network configuration to lattice types because finite ladder types with any phase shift must be accompanied by amplitude variations. In order to avoid the use of transformers in the lattice structure, a half-lattice will be chosen with the input terminals excited by two equal voltages 180 degrees out of phase. Such voltages are readily available from vacuum tube phase inverters consisting of a tube with equal cathode and anode loads.

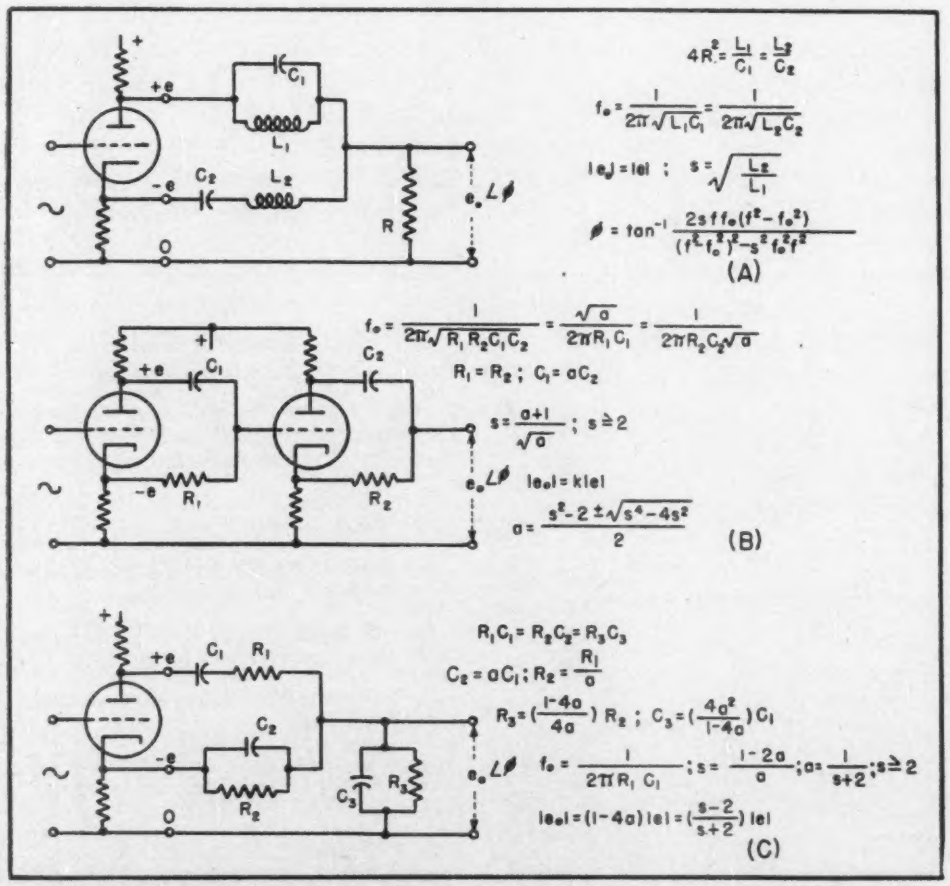


FIG. 1—Three networks for producing phase shift. Networks are used in pairs to obtain two outputs which have a constant phase difference over a wide range of frequency. Phase shift equation given for network of Fig. 1A holds for other two networks

L-C Lattice

A circuit having enough independent parameters to permit the designer to shape the phase angle curve to the required logarithmic form and the basic design equations of the circuit are shown in Fig. 1A. It will be noted from the equation for the phase angle (Fig. 1A) that an arbitrary factor s is included. The choice of s is up to the designer.

If s lies between 3 and 5, a fairly straight line for ϕ is obtained when plotted against a logarithmic frequency scale. As will be shown later, if a second curve for a second similar network, but with a resonant frequency f_o which is 4.53 times the resonant frequency of the first curve, is plotted, the phase

Phase Shift Networks

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Applications

THE wideband phase shift networks described herein are applicable to:

Single sideband telephony accomplished directly at the final carrier frequency without multiple modulators or sharp cutoff filters.

High efficiency broadcast transmitters radiating carrier, upper, and lower sidebands from three separate antennas.

Frequency variation of crystal controlled carrier of communication transmitters either for carrier control or frequency-shift keying.

Circular display on cathode-ray tubes over a wide frequency band without adjustment of the phase shift network.

Variable speed operation of three-phase a-c motors.

angle difference between these two curves is maintained within 90 ±4 degrees over a fairly wide range of frequency if $s = 4$, and is quite satisfactory for voice frequencies because the upper to lower frequency ratio is approximately 28 to 1, as for example would occur in a band from 130 to 3,600 cps.

The band can be widened indefinitely by adding more elements to the bridge arms with the result that the frequency range is expanded more until remarkably good performance is obtained over the full audio range from 30 to 15,000 cps.

The use of inductances in filters is to be avoided if possible because of the inability to obtain a pure inductance; there are always the inevitable series resistance and shunt capacitance. Other objections to the use of inductors are that they may pick up unwanted signals from stray magnetic fields and that they are not constant in inductance with applied voltage. As a consequence, a resistance-capacitance type of half-lattice network would be preferable providing the required type of phase curve were obtainable from them.

R-C Lattice

In order to provide a wide range of operation, two simple resistance-capacitance networks can be used in cascade with isolating tubes between them as shown in Fig. 1B. A single network has restricted bandwidth. No terminating resistor can be used in this type of network.

The phase angle of the final output voltage can be adjusted exactly as in the L-C circuit of Fig. 1A because the phase angle equation is identical. The only limitation with this network is that s must be greater than 2, however as previously found, for best results s should be approximately 4, and hence lies well above 2.

The number of stages included in cascade may, of course, be increased to any desired number. When six such stages are used, the frequency ratio for which a phase angle difference between two sets of networks can be maintained within 90 degrees ±3 degrees becomes approximately 200 to 1, or what would cover an audio frequency band of 50 to 10,000 cps, which is adequate for high quality broadcast service.

Another R-C network, which does not require an isolation tube, is shown in Fig. 1C. This network somewhat resembles the L-C network of Fig. 1A but differs in output voltage. The output voltage is a proper fraction of the input voltage. The factor a must be less than 0.25, or s must be greater than 2, when using this network. As previously pointed out, for best results s should be approximately 4, or $a = 0.167$, which will yield an output voltage of about 0.33 times the input voltage.

The phase angle equation (Fig. 1A) is seen to be identical to those for the previously described networks. In order to find the proper values for f_0 in the two networks which are to yield a phase angle difference of 90 degrees, assume a geometric mean frequency between the upper and lower frequency limits of usable phase angle difference. This mean frequency is not critical, but a value of 700 cps has been suggested as a practical frequency (O. B. Hansen, Down to Earth on 'High Fidelity', Radio Technical Planning Board, Report on Standards and Frequency Allocations for Post-War FM Broadcasting, Panel 5, June 1, 1944, Section VIII). Having decided on the mean frequency of the system, it is merely necessary to design the two phase shift networks so that one has a phase angle of 180 − 45 degrees at 700 cps, and the other a phase angle of 180 + 45 degrees at 700 cps.

Basis for Design

Suppose the value for f_0 of the first network is to be determined, then, designating f_0 of the first network as f_{01} and letting f equal the mean frequency, designated as F, the phase angle equation (Fig. 1) becomes

$$\tan \phi = \frac{2sFf_{01}(F^2 - f_{01}^2)}{(F^2 - f_{01}^2)^2 - (sf_{01}F)^2}$$

Setting $\phi = 135$ degrees and $s = 4$, clearing fractions and solving for f_{01} gives $f_{01} = 2.126F$, which, for $F = 700$ cps, gives $f_{01} = 1{,}488$ cps.

By reciprocal relationships, the value of f_{02}, the f_0 of the second network, is $f_{02} = F/2.126$; at $F = 700$ cps, $f_{02} = 329$ cps.

The parameters of the two networks can now be calculated. For convenience and to establish values of impedance into which vacuum tubes can work satisfactorily, assume that $R_1 = 20{,}000$ ohms in each

Table I—Determination of Network Parameters

First Network	Second Network
$f_{01} = 1488$ cps	$f_{02} = 329$ cps
$s = 4.00$	$s = 4.00$
$a = 0.1666$	$a = 0.1666$
$R_1 = 20{,}000$ ohms	$R_1 = 20{,}000$ ohms
$C_1 = \frac{1}{2\pi f_{01} R_1} = \frac{1}{2\pi 1488 \times 20000}$	$C_1 = \frac{1}{2\pi f_{02} R_1} = \frac{1}{2\pi 329 \times 20000}$
$= 0.00535\ \mu f$	$= 0.0242\ \mu f$
$C_2 = a\,C_1 = 0.166 \times 0.00535$	$C_2 = a\,C_1 = 0.166 \times 0.0242$
$= 0.000892\ \mu f$	$= 0.00403\ \mu f$
$C_3 = \left(\frac{4a^2}{1-4a}\right) C_1 = 0.333\ C_1$	$C_3 = \left(\frac{4a^2}{1-4a}\right) C_1 = 0.333\ C_1$
$= 0.333 \times 0.00535$	$= 0.333 \times 0.0242$
$= 0.001785\ \mu f$	$= 0.00806\ \mu f$
$R_2 = \frac{R_1}{a} = \frac{20000}{0.166}$	$R_2 = \frac{R_1}{a} = \frac{20000}{0.166}$
$= 120{,}000$ ohms	$= 120{,}000$ ohms
$R_3 = \left(\frac{1-4a}{4a}\right) R_2$	$R_3 = \left(\frac{1-4a}{4a}\right) R_2$
$= \left(\frac{1-0.666}{0.666}\right) 120{,}000$	$= \left(\frac{1-0.666}{0.666}\right) 120{,}000$
$= 60{,}000$ ohms	$= 60{,}000$ ohms

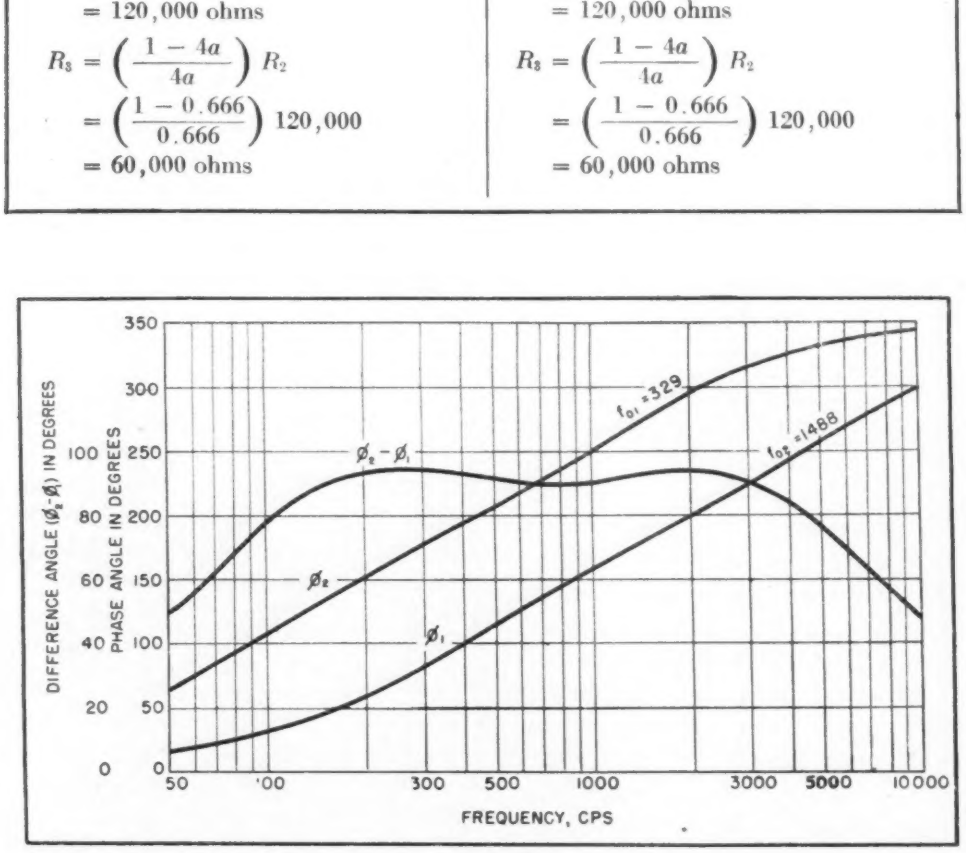

FIG. 2—Phase shift characteristics of networks whose values are given in Table I

network. The calculations are summarized in Table I.

The phase shift curves for these two networks are shown in Fig. 2. Note the long frequency range over which these curves are substantially parallel. The difference angle is plotted to facilitate comparison. Note that this difference angle holds fairly close to 90 degrees over a range of frequencies from 130 to 3,600 cps. This range is quite adequate for a voice frequency channel.

Such a network can be used to build a simple single sideband transmitter without the necessity of using sharp cut-off filters and double or triple modulation. This simplification may be done by combining the outputs of two balanced modulators: one balanced modulator is fed with radio frequency cos ωt and audio frequency $m\cos(\mu t - \theta)$, and the other balanced modulator is fed with radio frequency cos $(\omega t \pm \pi/2)$ and audio frequency $m\cos(\mu t - \theta \pm \pi/2)$. If the plus signs are used and the balanced modulator outputs are added, the resultant output would be $m\cos[(\omega - \mu)t + \theta]$, which is the lower sideband.

Single Sideband Telephony

An experimental system of this type has been constructed and operated using carrier frequencies in the broadcast band. No untoward difficulty was encountered and results were fully up to expectations. The transmitter was modulated with audio signals taken from the output of a broadcast receiver. The single sideband transmission was received by a second broadcast receiver into whose input terminals was also fed an unmodulated continuous wave radio frequency from a signal generator to furnish the missing carrier. The signal generator frequency was adjusted until the reproduced program sounded most natural. No auxiliary filters were used in the radio section of the transmitter to aid in reducing the unwanted sideband.

The question may arise as to how much of the unwanted sideband is permitted to get through the system if not exactly 90 degrees phase difference is obtained between the two audio channels. The ratio of the weaker sideband to the stronger sideband is given by the equation

$$\text{RATIO} = \sqrt{\frac{1-\cos\delta}{1+\cos\delta}} \fallingdotseq \frac{\delta}{2}$$

where δ is the deviation of the difference phase angle from $\pi/2$, with δ expressed in radians for the approximate formula. A deviation from 90 degrees of 6 degrees is required before the weaker sideband becomes 5 percent as strong as the stronger sideband, so that the phase angle curve of Fig. 2 is probably commercially useful over a range in frequencies included between 84 degrees on the low side of the center to 84 degrees on the high side of the center.

A second application for the system is that of providing a closer-to-zero frequency single sideband telephone or broadcast transmission when filters are used. For example, a single sideband transmitter may be constructed along conventional lines with a quartz crystal type of

band-pass filter to operate on 100 kc. Suppose the pass band extends from 100,600 to 108,000 cps. It is seen that frequencies below 600 cps are attenuated in such a system. Now if the single sideband system described in the present paper were to be used in conjunction with a filter, the filter could transmit from 100,000 to 108,000 cps, and the region between 27 and 600 cps could be taken care of by the audio phase shift system, letting the filter remove the undesired sideband from 99,400 down to 92,000 cps. Thus the resultant radiation could contain single sideband components corresponding to an audio frequency range of 27 to 8,000 cps instead of being limited to a range of 600 to 8,000 cps. The addition of the 27 to 600-cps range will add considerably to the naturalness of male speech and organ music. Frequencies between 0 and 27 cps should be removed from the original audio being fed into the system.

High Efficiency Transmitter

A high efficiency broadcast transmitter can be constructed by employing three power amplifiers and three antennas arranged so that an unmodulated carrier is radiated on a central antenna and the upper and lower sidebands are radiated respectively on two side antennas, which are on a straight line through the central antenna but on opposite sides equidistant from it. The sidebands are generated in much the same manner as described in the preceding section. Only one set of audio phase-shift filters are required, for the upper and lower sidebands can be obtained by simply adjusting the phases of the radio frequencies fed into the two sets of balance modulators.

This system of transmission could be accomplished with the following installed relative power capacity

Carrier	1.00
Upper Sideband	0.25
Lower Sideband	0.25
Total	1.50

When modulating 100 percent, this system will have an overall efficiency of about 66 percent, resulting in a d-c power consumption of 2.25 maximum. This consumption graduates down to 1.5 for zero modulation. For an average modulation of 50 percent the power consumption would thus be about 1.875.

The conventional double sideband plus carrier class-B amplifier must have an installed power capacity of 4.0 for handling the peaks of 100 percent positive modulation and the transmitter runs at 33 percent efficiency, requiring a continuous input power of 3.0 from the d-c supply. Thus the saving in d-c power consumption would be about 1.125 based on the carrier rating, or for a 50-kw transmitter, the saving would amount to 56.25 kw. Besides the savings in power costs, the system would have lower first costs in the water cooling system, power rectifiers and transformers, and in high power vacuum tubes. The replacement tube cost also would be less.

In the operation of emergency communications transmitters it is often desirable to change the radiated carrier frequency a few hundred or a few thousand cycles to avoid either intentional or accidental jamming, yet it is also desirable to retain the benefits of precise frequency control such as is provided by a quartz crystal. One solution is to have available a large number of crystals lying on closely adjacent frequencies selectable by a rotary switch. Another scheme might be to adjust the air gap or shunt capacitance across the crystal. All of these methods have their objectionable features.

Adjustable Carrier Frequency

An alternative arrangement is to make use of the single sideband generator already described. By way of example, suppose the assigned frequency of a transmitter were 4,500 kc. One could then use a crystal oscillator on 4,498 kc in conjunction with the balanced modulator and a 2-kc variable frequency oscillator to produce the required 4,500-kc carrier. The oscillator could then be adjusted to other nearby frequencies to avoid jamming, by having it cover a range of roughly 0 to 4 kc and thus be able to change the radiated frequency plus or minus 2 kc about the assigned frequency.

The frequency stability of the system would be quite similar to the master quartz frequency stability and hence could be classified as precise. Wider ranges of control could of course be obtained by utilizing submultiple crystal frequencies or wider oscillator range, within the limits of stability of the final frequency.

Frequency Shift Keying

A transmitter equipped as above could be easily converted into a telegraph transmitter with precise frequency shift keying. By way of example, suppose the 4,500-kc transmitter were required to radiate 4,499.9 kc with the key down and 4,500 kc with the key up. All that would be necessary would be to shift the low frequency oscillator from 2.0 kc to 1.9 kc. This shift could be accomplished by keying in a shunt capacitance, and the resulting frequencies would be both precise and stable, maintaining the 0.1-kc difference quite accurately over long periods of operation.

Other Applications

The two 90 degree phase angle displaced voltages can be fed into the X and Y deflection plates of an electrostatic deflection type of cathode-ray tube to obtain a circular trace. The pattern will remain circular for wide changes in frequency if one of these phase-shift networks is used. The circular pattern is a useful indication of the closeness to 90 degrees of the phase shift obtained from these circuits and can be used to determine their performance.

By employing the 90 degree phase angle displaced voltages and a reversed Scott connected transformer, three phase power can be developed from a single phase source. Such a circuit could be used to control the speed of a three phase synchronous motor. Varying the frequency of the original source would vary the motor speed.

PHOTOELECTRIC DUST METER

A phototube in an illuminated air duct continuously measures the quantity of light reflected by dust particles passing through the system. Applications include testing and rating the efficiency of air-cleaning devices

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CONVENIENT quantitatively meaningful methods for determining the dust content of air are needed.

The problem is of particular interest to the air-conditioning engineer who is confronted with the task of testing and rating air-cleaning devices, and to the experimenter in this field who desires quick but accurate measurements. An ideal measuring system for these purposes would be one which would give a direct and instantaneous indication of cleaning efficiency at all times, and would present this indication so that an untrained worker could read it accurately.

Former Methods

Previous measurement techniques have fallen short of the ideal. The following examples are cited to acquaint the reader with the nature of the prior art and its limitations.

(1) In one method, air is impinged onto a viscously-coated slide by the stroke of a piston, and the size and number of particles per unit area noted with the aid of a high-powered microscope.

Error arises from optical and mechanical discrimination against small particles[1], and human variations in making the count. Preparation and handling of the slide, and adjustment of the pump orifice, present complications. There is obviously considerable time consumed in making such a measurement, and the services of a trained worker are necessary.

(2) The increase in weight of a coated slide may be determined. This reduces the human error, but, in a weight determination, there is no way of knowing whether a given weight represents one particle of 1000 microns in diameter or a billion particles one micron in diameter.

(3) Dust-laden air may be forced through some filtering material or device, such as a cloth, at a uniform rate[2]. The time necessary to produce a given increment in weight or coloration of the filter may be taken as an indication of the dust-content of the air. Again the method is long and cumbersome, and appreciably selective in the size of particles retained.

In view of the limitations inherent in physical dust-measuring means, the authors have developed an overall system for testing the efficiency of air cleaners which gives an instantaneous and direct indication. The nucleus of this system is a phototube and a light source; the amount of dust in the air determines the illumination of the phototube and hence the current from it. This effect, when amplified, gives a continuous meter indication of the amount of dust in the air. By observations made before and after the cleaning device, the cleaning efficiency can be obtained by meter readings referred to a previously constructed calibration curve.

Photoelectric System

The first experimental test system is indicated schematically in Fig. 1. By means of this system the various parameters involved in the efficiency measurements could be examined. The system consisted of a closed air path; however, if the duct-work was opened at *A* (or

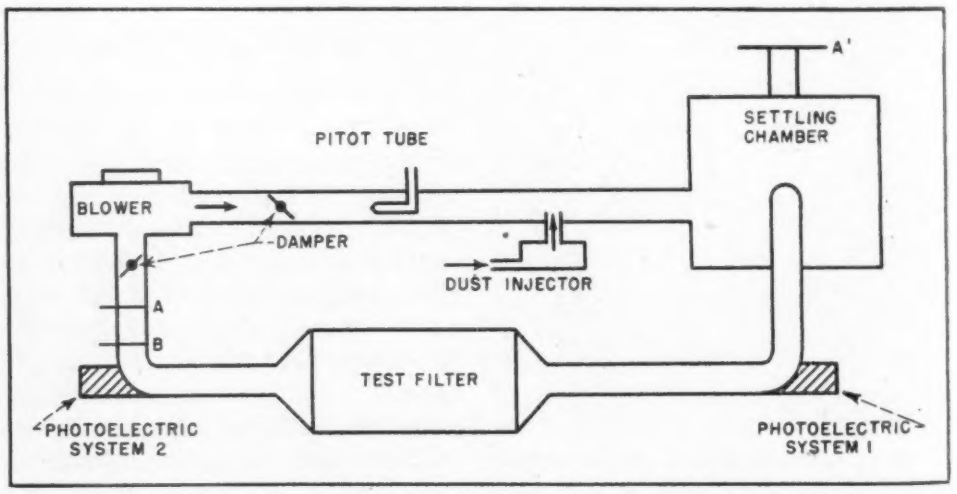
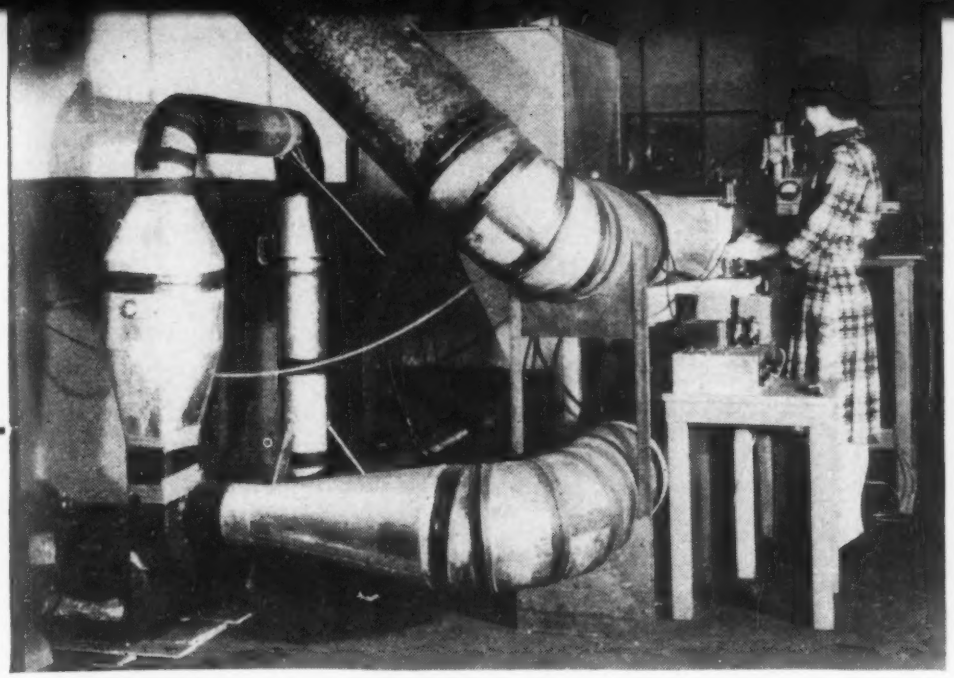


FIG. 1—Block diagram of an experimental dust measuring system



Photoelectric system for testing the efficiency of a filter for an air-conditioning unit

A') and B, air could be drawn through opening A (or A') and expelled through opening B.

The blower was capable of delivering 300 cubic feet per minute, the air velocity being controlled by adjustable dampers in the line. After leaving the fan, air passed through a section of duct containing a pitot tube for measuring the air velocity. Next in the system was the dust injector, which was connected to a compressed air line. By proper adjustment of the air pressure, dust could be fed into the system at a controllable and nearly uniform rate. From here the air passed into the bottom of the settling chamber, which was 3×3 feet in cross-section and 6 feet in height. Any large agglomerations of particles which might have existed in the air stream tended to settle out while travelling this six-foot vertical path at a low velocity.

The air stream then passed through a section of circular duct, and through an elbow on which was mounted a collimated light source and a collimated phototube. Next came the section in which the filter on test was placed. Following this was another elbow containing a dust measuring system, and a return duct back to the blower.

Quantities Measured

The photoelectric method of dust density measurement implies a determination of either (1) the quantity of light scattered onto a phototube by dust in the air, or (2) the quantity scattered away from the phototube by the dust. In the first arrangement, the phototube is shielded from the direct rays of the illuminating source and from extraneous reflections; ideally, the only light to reach the phototube is that scattered in a particular direction by the dust.

The second method uses a light beam shining directly at the phototube, which is collimated to look only at the source; dust between source and phototube then causes a decrease in phototube illumination by scattering light out of the beam. The precise nature of the scattering depends on the particle size and the wavelength of the light used.

One principal difficulty occurs in the case of direct viewing of the illuminating source by the phototube. The change in phototube current caused by dust in the intervening air is small compared to the constant current corresponding to clean air, unless the dust densities are excessively high or the light path exceedingly long. This means a loss in effective sensitivity.

Special measures might be taken to minimize this difficulty[3]. For example, a lens might focus the light onto a small absorbing target near the phototube, thus protecting the latter from direct rays. Another lens could then direct diffracted and reflected light to the phototube cathode. However, the use of lenses in a dust-laden system of this sort is generally undesirable since dust collected on them scatters light just as does airborne dust. These factors and other practical considerations favored the adoption of the indirect-viewing method.

Indirect Viewing

With an indirect viewing system, the illuminated dust particles are viewed at an angle to the illuminating beam. The use of an optical system here would serve only to increase the sensitivity of the phototube system. This same function can be performed by a suitable electronic amplifier, which is more desirable than an optical system. Since extreme sensitivity is available with the use of photo-multiplier tubes and high-gain amplifiers, a consideration of relative intensity of light scattered along, versus normal to, the incident beam is of little importance in this connection.

If the dust has a random particle size distribution ranging in size from larger to smaller than the wavelength, λ, of the incident light, the light scattered normal to the beam would be made up of that due to reflection from the larger particles and that due to absorption and reradiation from the particles smaller than λ. This latter is the well-known Rayleigh scattering, the law of which predicts that the shorter wavelengths should be scattered more intensely than the longer ones due to an inverse fourth-power dependence on wavelength.

As a further consideration, the particle distribution before the air passes through the cleaner would differ from that after cleaning, since any air cleaner is somewhat selective with regard to the ease with which it collects particles of a particular size[4, 5]. This means that the ratio of reflected to reradiated light would have changed after cleaning.

Since reflection depends on the square of the particle radius, and reradiation depends on the radius cubed, interpretation of results would become very difficult. For the above reasons it was desirable to restrict the types of dust to those with particle diameters all larger or all smaller than the wavelengths of the illuminating radi-

ation to which the phototube is sensitive. If the phototube current is to be directly proportional to the number of particles in the air, then they should also be sufficiently similar in size to make the selectivity of the cleaner negligible over the range of particle sizes.

When all the above conditions are met, the intensity of illumination of the phototube cathode will be proportional to the number of dust particles in the air. If the relation between phototube illumination and phototube current is known, the observed phototube current will be a direct indication of the number of particles per unit volume of air.

A relation for efficiency in terms of the meter currents, involving the various parameters, may be obtained as follows: Suppose we assume two complete and independent measuring systems, one before and one after the cleaning device. The primed quantities refer to the latter system.

i = Current through indicating meter in microamperes

C_t = Current response of phototube to illumination in μa per lumen

C_a = Gain of amplifier

I_o = The number of lumens from the light source falling on an area perpendicular to the lightbeam, this area being defined by the intersection of the lightbeam limits and the projected limits of the phototube cathode

A_s = Dimensionless reflection and scattering constant due to the surfaces of the apparatus viewed by the phototube

A_d = Dimensionless reflection and reradiation constant due to the airborne dust

r = Dimensionless constant representing reflection from airborne dust

s = Dimensionless constant representing reradiation from airborne dust

$f(d)$ = Dimensionless value representing the effect of the particle size distribution of airborne dust

P = Number of particles of airborne dust per unit volume (dust density), dimensionally a reciprocal volume

Then the meter currents, i before cleaning, and i' after cleaning, are given by

$$i = C_t C_a I_o (A_s + A_d)$$
$$\text{and } i' = C'_t C'_a I'_o (A'_s + A'_d)$$
$$\text{or } i = mA_d + i_o \text{ where } m = C_t C_a I_o$$
$$\text{and } i_o = C_t C_a I_o A_s = mA_s$$
$$\text{and } i' = m'A'_d + i'_o \text{ where } m' = C'_t C'_a I'_o$$
$$\text{and } i'_o = C'_t C'_a I'_o A'_s = m'A'_s$$
$$\text{but } = A_d = arsf(d)P$$

where a is the proportionality constant (dimensionally a volume)

$$\text{or } P = kA_d \text{ where } k = \frac{1}{arsf(d)}$$

The efficiency E is then

$$E = \frac{P - P'}{P} = \frac{\frac{k}{m}i - \frac{k'}{m'}i' - kA_s + k'A'_s}{\frac{k}{m}(i - mA_s)}$$

The efficiency is seen to be an explicit function of the various parameters. A calibration run associated with each set of measurements is obviously necessary when two independent systems are used.

Ideally, the use of dust of a uniform particle size of a single material will cause the difference between k and k' to become negligible. Assuming a linear response of the phototube system, a single light source, phototube, amplifier, and meter for each measurement would cause m and m' to become equal, and proper design would cause A_s and A'_s to become negligibly small. The equation for efficiency would then reduce to

$$E = 1 - i'/i.$$

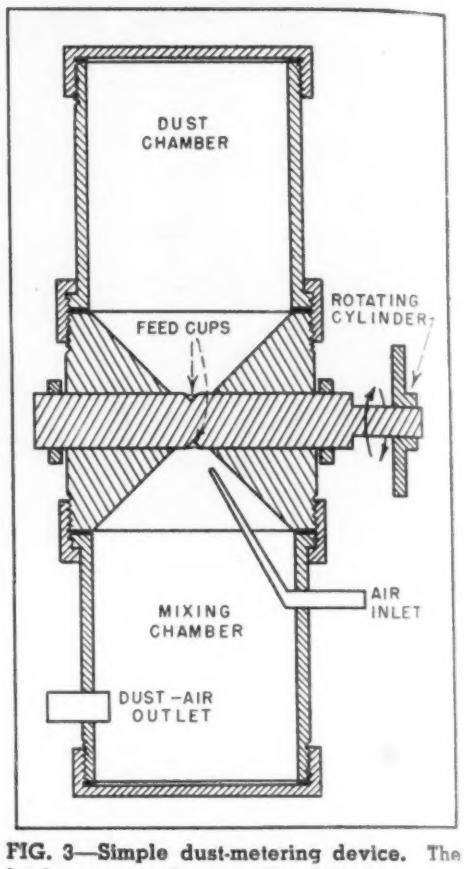


FIG. 3—Simple dust-metering device. The feed cups on the rotating cylinder carry dust from the upper chamber into the mixing chamber

Circuit

When the test stand was put into operation, certain problems arose affecting the accuracy of results. Due to the high sensitivity of the response of the multiplier type of phototube to variations of electrode voltages, the use of a power supply with good regulation was imperative. Figure 2 shows a schematic diagram of the complete electronic circuit. A mu-bridge type of regulator is used to insure constancy of the phototube electrode voltages.

The noise level in this type of phototube is proportional to its d-c output. This permitted the use of an a-c amplifier in the measuring system, which is desirable because of its simplicity compared to an equally stable d-c amplifier.

The resistance-capacitance network associated with the microammeter has a sufficiently long time constant to allow the meter reading to be an average indication of the response of the phototube. This expedient was resorted to because

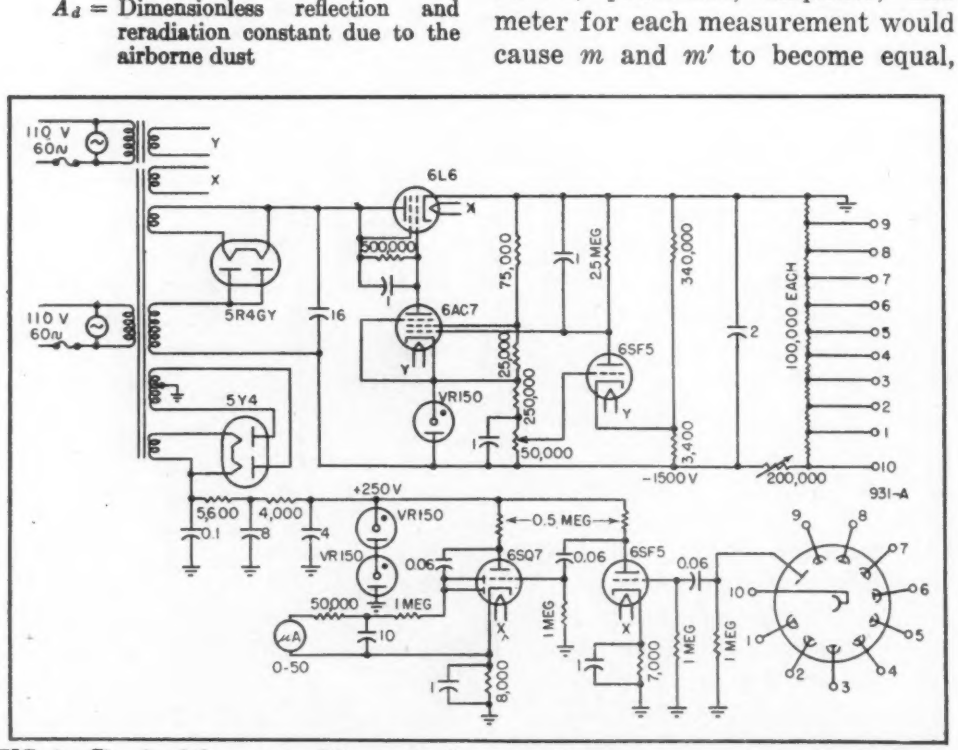


FIG. 2—Circuit of the a-c amplifier and voltage-regulated power supply for the phototube

of the failure of the original dust injector system to give an entirely uniform feed at the low dust levels desired. A metering type of dust injector shown in Fig. 3 was finally adopted. The dust content of the air can be varied by varying the speed of rotation of the notched cylinder.

Calibration

Silicic acid dust was used in the tests. As it came from the manufacturer, it was found to have a considerable range of particle size. Uniformity of particle size was obtained by a settling fractionation technique, using water as a settling medium. To reduce the tendency to agglomerate after drying, the yield was heated to a temperature appreciably below the sintering point.

Using the system as a closed circuit, calibration runs at low dust levels were made by the successive introduction of known quantities of dust at equal time intervals. Under this condition the reading of the indicating meter was proportional to the increase of the dust density. The range of dust densities over which this linear response was observed embraced values from approximately normal room densities to an order of magnitude higher than normal room densities.

When the same type of measurement was repeated using dust densities ranging from normal room density to values approximately two orders of magnitude higher, the response was observed to deviate from linearity. Two effects were found to be responsible for this deviation. The first and most obvious effect was the tendency of dust to settle and adhere to the surfaces of the apparatus. Density changes due to this effect would be roughly proportional to the density. Secondly, the phototube system was found to have, very closely, a square-law response to illumination.

This measurement was made by stopping down the light source while keeping the color temperature of the lamp filament constant, an expedient necessary to eliminate any effect of color sensitivity of the phototube. From quantitative data on the decrease in dust density due to settling and adhesion, and the use of the phototube system response curve, it was found possible to predict the nonlinear response which was observed over the wide range of dust densities used.

Final Design

With the experience gained in the previous investigations a redesign of the test system was undertaken. Figure 4 shows a diagram of this design. Efficient filters clean the intake air to give a zero dust level. The whole system is on the low-pressure side of the blower to facilitate the introduction of dust or smoke.

A single unit of phototube and associated electronic equipment is used to observe the dust level on both sides of the cleaning device. To minimize mechanical difficulties, two light sources are used, but those are made easily interchangeable so that the effect of any differences due to them are readily observed and taken into account. With proper design and occasional easy cleanings, the difference in zero dust level reading of the two observation points may be made negligible.

The air velocity is maintained at a sufficiently high value to minimize the retention of particles on the duct walls. A value of 6.5 feet per second was originally used, but experience indicated the advantage of somewhat higher velocities. In this connection, one must not lose sight of the variation of filter efficiency with air velocity.

A dust measuring system similar to that shown in Fig. 4, incorporating the above features and observing the suggested precautions, gives quick and accurate results. The indication is continuous, and hence of great value to the experimenter when observing the relation between any of several variables and the quantity of dust in the air. When working in the region of dust levels where the phototube response is linear, efficiency readings will be quite accurate, since they are obtained from relative readings. The technique is also applicable to factory checking of air filters, since the equipment, once adjusted, will provide efficiency ratings simply and rapidly in the hands of an untrained operator.

A major part of the work covered by this article was done under the direction of Wilson P. Boothroyd.

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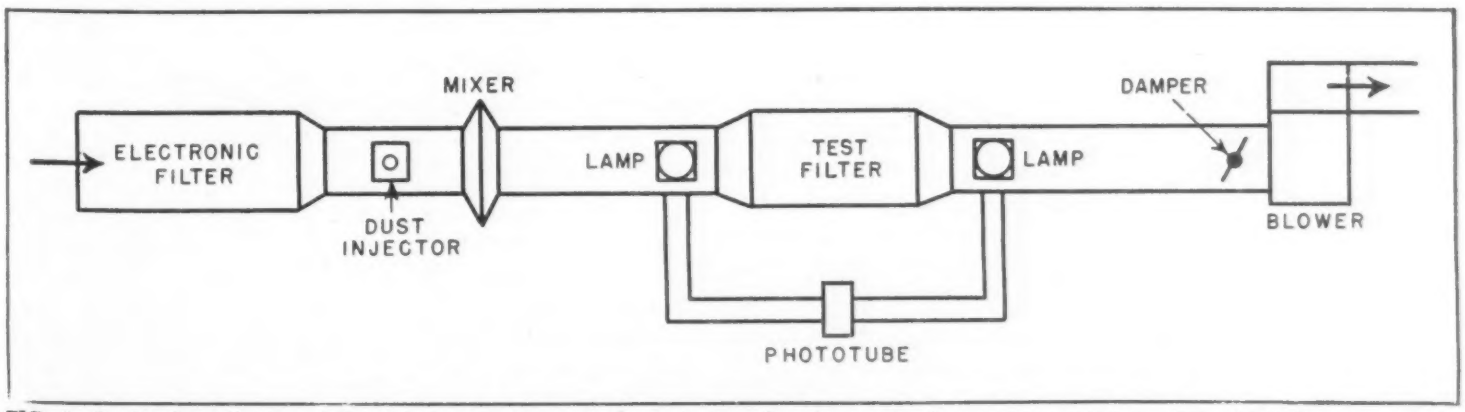

FIG. 4—In the final design of the dust measuring system, air is introduced into the duct at low velocity. One phototube serves both sides of the filter

NOISE and O

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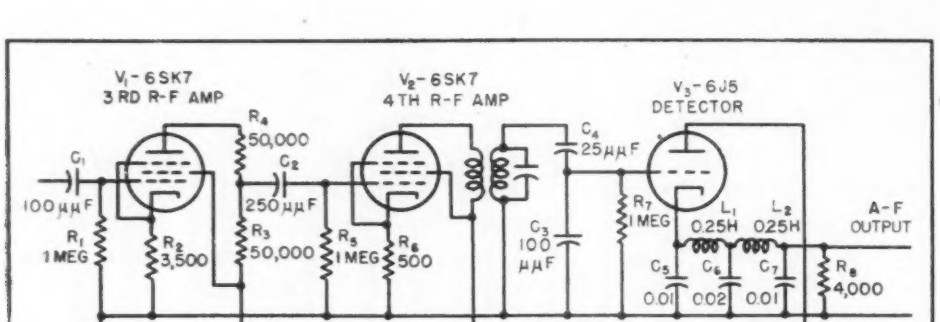

FIG. 14—R-f output limiter depending on plate current saturation in the last two r-f stages, with low-pass filter following the detector to further improve the signal-to-noise ratio of the receiver

INSTANTANEOUS series-type, balanced, and shunt-type noise-peak limiters acting in conjunction with a diode second detector were analyzed in the first part of this paper, (p114, Nov. 1946), along with a noise-peak limiter that acts entirely in the i-f amplifier system. The next circuits to be considered are output limiters, which differ from the instantaneous noise-peak limiters primarily in that they simply present a continuous limit on the maximum power output from one or more amplifiers at some predetermined level. They are, in general, difficult to bias automatically to provide limiting at a desired depth of modulation of the carrier independent of the absolute carrier value, and are therefore mainly useful on c-w (telegraph) operation.

R-F Output Limiter

R-f output limiting (with incidental r-f noise limiting) is quite satisfactorily achieved with the simple circuit arrangement of Fig. 14, which depends on vacuum-tube plate current saturation and control grid cutoff, with maintenance of a high input impedance in the control grid circuits of the saturated tubes. The third and fourth r-f amplifier stages are used as saturation limiters by operating with about 45 volts applied to both screen and plate circuits. The two stages combined provide the equivalent gain of one r-f amplifier stage at a much lower limiting level than is feasible with one stage alone, by virtue of r-f voltage dividers R_3-R_4 and C_2-C_4. The single tuned circuit following the fourth stage filters out r-f distortion caused by the preceding limiter circuits and provides further selectivity, while the low-pass filter following the detector further purifies the audio output and improves signal-to-noise ratio.

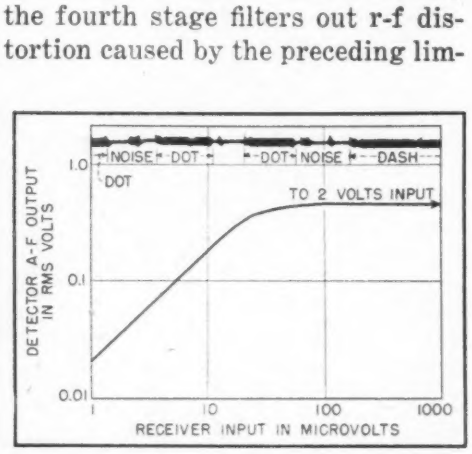

FIG. 15—Resonant overload characteristics of receiver using r-f output limiter for long-wave c-w reception, and oscillogram of letter V as received from an overseas transmitter in presence of 12-volt noise peaks. Input signal frequency is 16 kc, unmodulated; beat oscillator is on; a-f output frequency is 1,000 cycles. Distortion figures for detector output are 0.7 and 0.1 percent respectively for 2nd and 3rd harmonics with receiver input of 10 microvolts, and 2.9 and 0.9 percent for 500,000-microvolt input

The initial a-c input resistance of the third r-f amplifier tube is about one megohm, until the applied signal voltage exceeds the negative bias supplied by the voltage drop across cathode resistor R_2 to the control grid, when it drops to about one-half megohm because the grid becomes, in effect, a diode rectifier conductive for that portion of the positive half-cycle during which the signal exceeds the grid bias.

The negative bias thus developed across grid leak R_1 by grid rectification is applied to the control grid to limit the increase in space current. During a noise peak, then, the effective positive instantaneous voltage on the grid is the difference between the rectified voltage across R_1 (maintained by charging C_1) and the positive half-cycle voltage of the noise peak, with limiting effects in the plate circuit due to plate saturation.

On the negative half-cycle of r-f input, grid cutoff limits the change in plate current of the tube. The phase shift from grid to plate circuit results in the positive noise peaks applied to the grid of the third r-f amplifier tube appearing as modified negative peaks at the grid of the fourth r-f amplifier, where they are further limited by grid cutoff, the positive peaks at this point being also limited in the

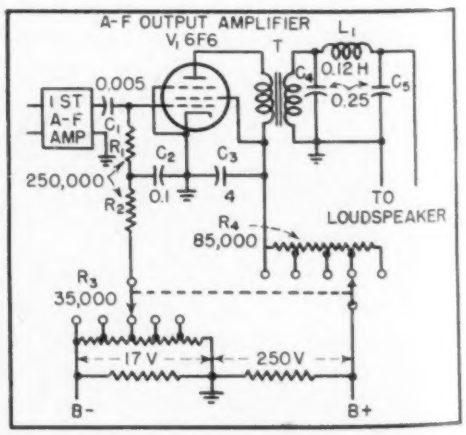

FIG. 16—A-f saturation-type output limiter

OUTPUT LIMITERS

Part II

Six versions of r-f and a-f output limiters, an f-m discriminator for a-m limiting, limiter design considerations, and recommendations of best choices for mcw and c-w operation conclude this comprehensive survey of limiters for a-m communications receivers

fourth amplifier plate circuit by saturation effects. The combined effect of the two limiter tubes thus is to limit both peaks of applied r-f voltage, whether due to signals or noise peaks.

Conventional bypass capacitors and screen filters are not shown in the circuit diagram but are actually used in the circuits themselves. The detector, an infinite-impedance or cathode-follower type, is used primarily for its low output impedance, and does not provide any desired limiting action. This saturation-type limiter is useful chiefly for c-w reception at very low carrier frequencies, though with a suitable saturation limit and an exceptionally good avc system controlling the preceding r-f gain to just below limiting level on the desired signal, distortion on mcw reception can be kept low over a considerable range of carrier input values.

Use is made in f-m receivers of similar limiting in the i-f system, except in those having limiting discriminators of the ratio type. Such i-f limiters usually do not, however,

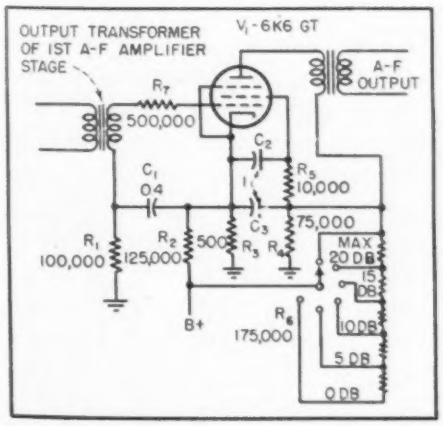

FIG. 17—Modified saturation-type limiter

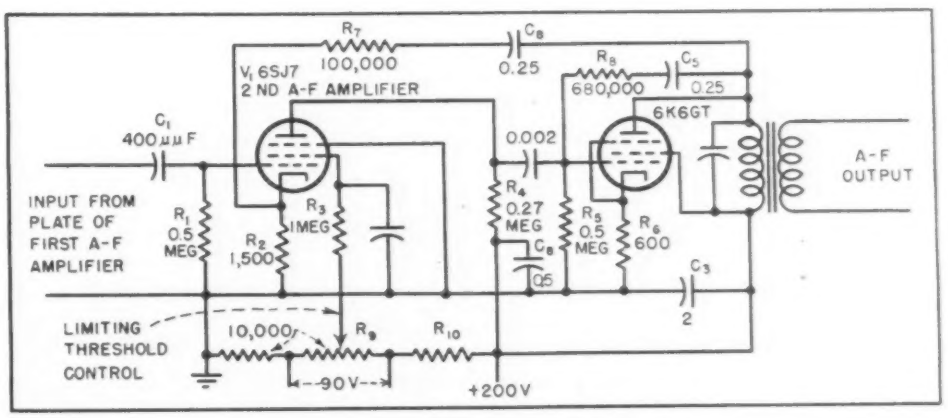

FIG. 18—Interstage a-f output limiter

utilize voltage dividers. They are designed for higher limiting levels than the circuit of Fig. 14, and operate to reduce amplitude variations of the f-m carrier appearing at the discriminator to the greatest practicable extent. The avc voltage may be taken from the final limiter grid resistor, or the preceding one if there is more than one limiter stage.

Figure 15 shows the resonant overload and distortion characteristics of a receiver utilizing this type of limiter and oscillogram of the letter V as received at 16 kc from an overseas transmitter in the presence of 12-volt noise peaks.

A-F Saturation-Type Output Limiter

Control of the saturation level of the a-f output pentode tube at various screen, plate, and control grid voltages provides audio output limiting action without use of additional tube circuits (Fig. 16). A low-pass filter ($L_1 C_4 C_5$) filters out distortion produced in the output stage; its cutoff frequency is 1,200 cps, and hence for a 1,000-cps tone signal the harmonics will be filtered out to a considerable degree.

The control grid, screen, and plate voltages in this limiter are varied by a double-pole switch that contacts taps on resistors R_3 and R_4. The voltages thus obtained maintain the gain below saturation fairly constant for all switch settings, while at the same time permitting control of the limiting level. This circuit is useful for c-w reception only. Below limiting threshold, there is a change in gain of about 3 db for a 20-db range of limiting threshold. It is highly desirable with output limiters that the gain below limiting threshold remain as nearly constant as possible for all settings of the threshold control.

Modified A-F Saturation-Type Limiter

By using a partly fixed-bias and partly self-bias arrangement in the cathode circuit of the output tube, output saturation threshold control is obtained in the circuit of Fig. 17 by varying only the common d-c plate and screen grid voltage supply to the tube. This is done in steps giving changes of 5 db in output limiting level. Resistor R_7

in the control grid circuit of the output tube reduces a-c loading, and prevents excessively high direct current through the secondary winding of the interstage a-f transformer when rectification occurs in the grid circuit of the output tube. This limiter is useful for c-w reception only. There is some loss in gain below limiting threshold for the lower levels of limiting, amounting to about 5 db for about 21 db of threshold adjustment.

Interstage A-F Output Limiter

The circuit of Fig. 18 obtains its output limiting effect in the a-f stage preceding the output stage, and employs some degenerative feedback to the limiting amplifier from the output amplifier as an aid in maintaining the gain below the limiting threshold as nearly constant as possible.

Limiting is done interstage primarily because of the low limiting level of 60 microwatts required in this case for the minimum threshold value, this low level being difficult to obtain with the audio output tubes usually incorporated in Navy receivers. For a limiting level range of 20 db, this circuit gives a change in gain below threshold of about 10 db, and a change of 16 db for a limiting level range of 30 db. These comparatively large losses in gain for the lower limiting levels are due to the low minimum limiting level required.

Full-Wave Shunt A-F Output Limiter

Two diodes in a single 6H6 envelope, connected interstage as in Fig. 19, serve as a full-wave shunt type of audio output limiter. One diode shunts plate load R_4 of the interstage a-f amplifier tube for the positive and the other for the negative half-cycles of the audio signal. The diodes are biased in series with a d-c voltage obtained from R_7, which thus controls the threshold level above which they become conductive on audio peaks. The diode impedance when conducting at the usual operating audio voltage levels involved averages only a few thousand ohms (the actual value depending mainly on the resistance of that part of R_7 between the variable contact and ground, plus R_6, and also on the audio voltage values), so that the plate load of the preceding amplifier drops from a value of about 250,000 ohms below limiting threshold to perhaps 5,000 ohms during limiting action.

With a high plate-impedance tube, such a load change will produce about 30 db less amplification above the limiting level than below it. This loss of amplification, combined with normal saturation effects in the preceding amplifier tube, limits the output peak voltage to a value that cannot exceed the d-c limiting bias of R_7 by any considerable amount. This limiting system is considered to be among the best of the audio output limiters for c-w reception. For a limiting level range of about 20 db, the change in gain below limiting threshold is only 2 or 3 db.

Figure 20 shows the resonant overload characteristics of this type of limiter as used in a typical receiver. The change in gain from LIMITER OFF to ON condition is caused by switching out a pad in the a-f amplifier system.

The circuit shown in Fig. 21 was used to investigate the possibility of providing output limiting without serious audio distortion by virtue of exponential nonlinear response, the theory being that a logarithmic increment in output for a linear increment of input would not cause distortion sufficient to destroy intelligibility.

Logarithmic Limiter or Compressor

The arrangement consists of a two-stage a-f amplifier, with degenerative feedback from the plate circuit of the output tube to the cathode of the preceding stage. Two diodes are connected in series with the feedback path, in such a way as to provide a path for both positive and negative half-cycles of the feedback voltage. Potentiometer R_{10} across a battery provides d-c bias to the diodes for setting the limiting level. The diode d-c circuit resistance is kept low to take advantage of low diode internal impedance values varying at an exponential rate with applied voltage. Using the diodes in this manner as feedback impedances is equivalent to varying the feedback percentage from a low value to a maximum as the instantaneous feedback voltage rises, with the reverse effect as the instantaneous feedback voltage falls.

When the instantaneous feedback voltage exceeds the region relative to diode impedance wherein that impedance is effective in determining feedback current, the circuit returns to linear operation. Within the nonlinear portions of the output characteristic, this circuit produces considerable distortion on speech or music but does not destroy intelligibility. Noise interference is reduced substantially,

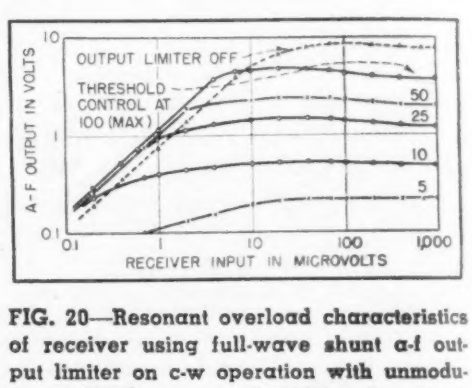

FIG. 20—Resonant overload characteristics of receiver using full-wave shunt a-f output limiter on c-w operation with unmodulated 500-kc input and 1,000-cycle output. Curves continue essentially flat out to 2 volts input

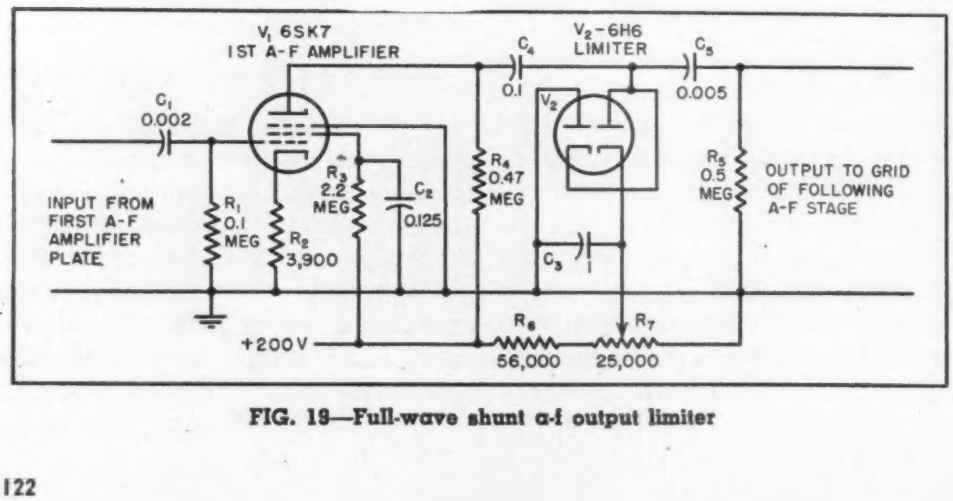

FIG. 19—Full-wave shunt a-f output limiter

and almost as effectively in some cases as with a series noise-peak limiter, if the desired signal is kept within the first linear portion of the output characteristic while noise peaks extend into the compressed region beyond.

Figure 22 shows typical characteristic curves obtained with this limiter arrangement.

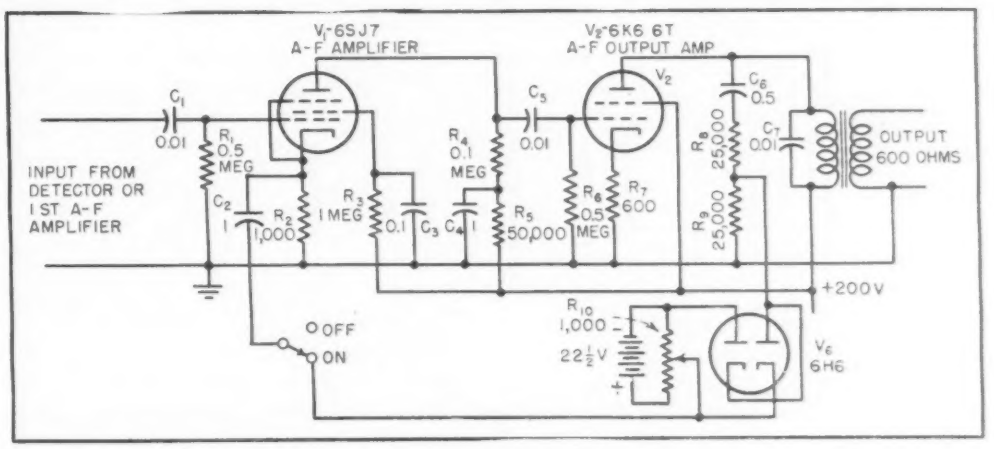

FIG. 21—Logarithmic limiter or compressor, employing two diodes in the degenerative feedback path

Other Limiter Arrangements

If a frequency-modulation receiver employing a discriminator of, perhaps, the Foster-Seeley type is tuned to amplitude-modulated signals, two peaks of maximum response will usually be evident, corresponding to the two points of maximum discriminator current. Since the two halves of the discriminator characteristic are the result of the differential voltage derived from two opposing detectors, the noise output of such a discriminator will be relatively low with no signal input as compared to an ordinary amplitude detector preceded by the same amplifiers. The discriminator provides a somewhat better signal-to-noise ratio on an amplitude-modulated signal tuned to one of the peaks of discriminator response, which is particularly apparent with relatively low modulation frequencies (narrow discriminator characteristic), and especially on keyed c-w signals. It should be noted that the discriminator used in this way reduces the useful bandwidth of the overall selectivity characteristic preceding it to about half of what it would otherwise be with the usual a-m detector.

The discriminator may be followed by a low-pass filter cutting off at about 200 or 300 cps and a d-c amplifier (capable of passing up to these frequencies) which operates a keyer tube controlling a local tone oscillator. Such an arrangement is capable of providing some really startling performance on keyed c-w signals in the presence of noise interference which would make reception with the usual receiving system, even with noise-peak limiters, absolutely hopeless. The use of the local keyer circuit eliminates one of the two peaks of reception, since the discriminator output polarities are opposite for its two maximum response points and the usual keyer tube circuit is arranged to respond to one polarity only. This scheme is subject to various disadvantages when adapted to a conventional a-m receiver, such as complexity and rather critical operating adjustments, but within its limitations has much merit. Figure 23 is typical of such circuits. The similarity of this arrangement to receiving systems for frequency-shift keyed signals is evident.

Using an f-m discriminator for a-m reception is, of course, a variation on the old proposal of providing two reception channels, one receiving signal plus noise and the other noise only, with the outputs of the two channels appropriately opposed or bucking. This proposal in its usual form does not work satisfactorily, due to the inherent difficulties of balance between such channels and the difference between them in decay time of the noise wave trains. The success (rather limited) of the discriminator version is mainly due to having a very small percentage difference in frequency between discriminator peaks of response as compared to the proposal mentioned, to inherently automatic balance when the discriminator characteristic is symmetrical, and to the single-channel amplifier preceding the discriminator.

Various other modifications of the general scheme of using a discriminator on a-m reception, some in conjunction with noise-peak and other limiters, have been evolved, and preliminary reports have indicated that considerable noise reduction effects have been obtained. The number of circuits and components involved, unfortunately, appears to have resulted in much additional bulk and complexity.

Thermionic Diode Characteristics

A diode of the thermionic type may be considered, for the purposes of this report, as a unidirectional variable resistor in series with an internally generated d-c potential due to cathode emission. For instance, in the 6H6 type of diode, this apparent internal potential appears to be about 1.2 volts and of such polarity as to result in electron flow from cathode to plate within the tube when the external plate-to-cathode path is completed. The effective value of the internal series resistance depends on both the d-c circuit resistance external to the diode and the external applied voltage.

If there is an external d-c circuit resistance of 1 megohm, for example, the internal resistance of each 6H6 diode is in the neighborhood of 600,000 ohms when 1 volt positive external potential is applied to the plate (as by a rising noise-peak), while at 10 volts it is about 35,000 ohms, as shown in Fig. 24. The curve is drawn as an average of quite widely scattered measured values.

Thus the measured shunting effect of the limiter diode is not very appreciable in a circuit like that of Fig. 11 until the noise peak voltage appearing across it approaches 10 volts. With a 1-volt desired signal also appearing across the detector diode load, it would seem to the operator as though the limiter were not functioning. In

addition, during the period in which the limiter diode internal impedance is low, it provides a path effectively shunting out the resistance in the long time-constant circuit (R_3C_2 in Fig. 11), thereby accelerating the charging-up of C_2. As the voltage across C_2 approaches that appearing between the limiter cathode and ground, limiting ceases. From these considerations, it is apparent that the shunt-diode type of limiter will be peculiarly vulnerable to the modulation envelope set up by the longer wavetrains of interference occurring at the lower frequencies for a given pulse of excitation at the antenna.

Inserting a suitable value of resistor in series with the limiter cathode, as in Fig. 12, will extend the charging time of C_2 when the limiter diode impedance is low, in addition to providing voltage divider action relative to the succeeding a-f amplifier. It is for these reasons that the circuit of Fig. 12 out-performs the simple shunt limiter so greatly, although only approaching the performance of the simple series limiter.

The series type limiter operates to open the circuit to the a-f amplifier. Once the internal potential of the limiter diode itself plus the external no-signal potential applied to this diode by the associated detector diode has been overcome (as it may be by a relatively weak signal or even by inherent receiver noise), further negative biasing of the limiter diode by a noise peak will open it, so that it becomes, in effect, an extremely high resistance, resulting in practically no signal being transmitted to the succeeding a-f amplifier. Precautions should be taken to avoid shunting the limiter diode by the stray capacitance of wiring, switches, etc. Since the diode is open on noise peaks, it will not shunt the resistance of the long time-constant circuit (R_1C_2 in Fig. 1) and so will not abrogate the functioning of that part of the limiter. This characteristic makes it of great value even in receivers designed for as low as 15-kc carriers.

Where it is of importance, the diode internal potentials which may delay functioning of the series limiter in the presence of very weak signals may be bucked-out by, for instance, a suitable battery in series with the limiter cathode resistor. It should be noted that shunting this cathode resistance with any substantial value of capacitance in an attempt to obtain a capacitance voltage-divider for the open condition of the limiter diode should be avoided, as it generally results in increased distortion of the desired signal.

On weak signals, the insertion loss of the series limiter is perhaps 3 db, while on strong signals there is practically no such loss. By insertion loss is meant the change in desired-signal gain of the receiver when switching from LIMITER OFF to ON condition, as measured with signal modulation percentage below the threshold of limiting. In the absence of noise peaks exceeding the preset threshold of limiter action, the limiter diode is biased to closed condition

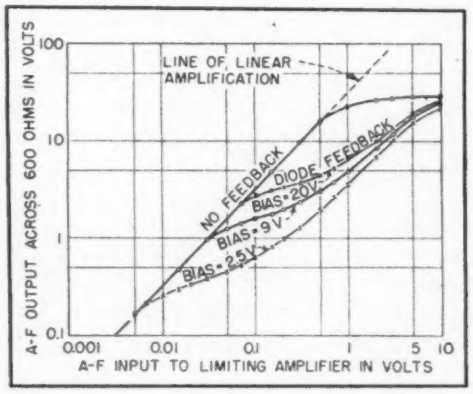

FIG. 22—Typical characteristic curves for receiver using logarithmic limiter, with 1,000-cycle a-f input

by a relatively low external voltage when a weak signal is present, resulting in a high value of internal resistance in this diode, with attenuation of input to the succeeding amplifier by voltage divider action. On a strong desired signal, however, the external diode biasing voltage is much higher, with much lower diode internal resistance, and the insertion loss is minimized.

Crystal Diodes

Diodes of the crystal type may be utilized in place of the thermionic type in the various limiter circuits designed for diode use. For such purposes, the crystal must be capable of operation without damage at relatively high impressed voltages and fairly large instantaneous currents. Crystals of the silicon and similar varieties are therefore unsuitable, due to their inadequate voltage and current handling capabilities, but germanium crystals may be considered for such service. It should be remembered, however, that the various crystal diodes have relatively low back resistance compared with thermionic diodes, and also that their inverse current characteristics have peculiarities of slope that cannot be neglected in some applications. Further, since the back-resistance is relatively unaffected by the d-c load resistance with which the crystal is used, while the forward resistance increases with increased load resistance, the actual values of resistance incorporated in limiter circuits using crystal diodes become of prime importance in determining limiter effectiveness. The temperature-sensitivity of crystal diodes will also have to be seriously considered for some applications.

Limiter Input Levels

In general, it is desirable to have control of the a-f gain following instantaneous limiters of any type. This, of course, is normal for AVC ON operation, but should also be true for AVC OFF or c-w operation. The shunt limiters operate better with low a-f gain following, and with a high r-f input level at the associated detector. The series diode limiters are usually inoperative, as regards limiting, until their internal diode potentials are exceeded, something also most readily accomplished with the highest possible signal input to the detector.

Progressive Limiting in Amplifiers

All amplifiers are, of course, limiters as their maximum output capabilities are approached. Advantage can be taken of this characteristic to prevent blocking, or a decrease of signal output from a receiver with increasing input during AVC OFF operation. The average r-f pentode of the semiremote or remote cutoff type will withstand an r-f input of about 10 times the value required to just initiate appreciable overload before its maximum output begins to drop. For

example, by appropriate choice of plate load, it is possible even with normal d-c electrode potentials to have the i-f amplifier preceding a last i-f stage begin to overload before the last i-f stage begins to block, to have the amplifier preceding the next-to-last begin to overload in its turn, etc.

With five properly designed i-f or r-f stages preceding the final detector, for instance, it is possible to provide satisfactory protection against blocking in this way over a range of about five orders, or 100,000 times the input which initiates overloads of the last i-f stage. While of maximum utility on c-w operation, such a characteristic will also be of use on mcw operation with avc off, since even though distortion of voice signals is very high, their presence will nevertheless be evident. This means can also be very useful in protecting detectors and audio limiters against excessive overdrives which tend to abrogate their characteristics.

Linear Detection

Linear detection is to be preferred for the final detector stage, not only for the reasons of low distortion and discrimination against weak undesired signals in the presence of relatively stronger desired ones, but also because of behavior with regard to noise. In the linear region of detection, increase in the signal input level to the detector will not be accompanied by substantial increase in the noise output due to internal noise modulation of the carrier within the receiver, a highly desirable condition.

Desirable A-F Amplifier Characteristics

The frequency response of the a-f amplifier following the detector should be restricted to a range not exceeding the requirements for satisfactory voice reproduction, or the fidelity permitted by the selectivity preceding the final detector, whichever is the lesser. The high-frequency cut-off for good voice intelligibility is, however, about 3,500 cps, and the selectivity preceding the detector should not, in general, abrogate this requirement.

Audio systems which have poor transient reproduction characteristics may tend to magnify the effects of noise pulses. The tendency toward damped oscillations or hangover on sharp peaks of input in such systems may be reduced by the use of low-impedance output tubes (triodes) or by a sufficient degree of degenerative feedback from the output, and also by the provision of properly designed output transformers, properly loaded.

Circuit Diagrams

The circuit diagrams in this report have been prepared with the intent of showing, as clearly as possible, the circuit configurations in their most readily comprehensible form. It has been the author's experience that this is absolutely essential for an understanding of limiter circuits particularly, and seemingly novel circuit arrangements have often revealed their similarity to or identity with one of those covered in this report upon redrawing.

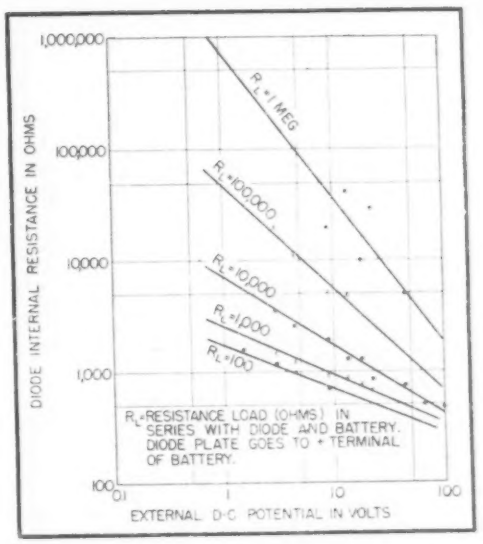

FIG. 24—Diode internal resistance at various external load resistances and applied d-c potentials, for a 6H6 diode element. Values are derived on basis of 1.2 volts diode apparent internal potential

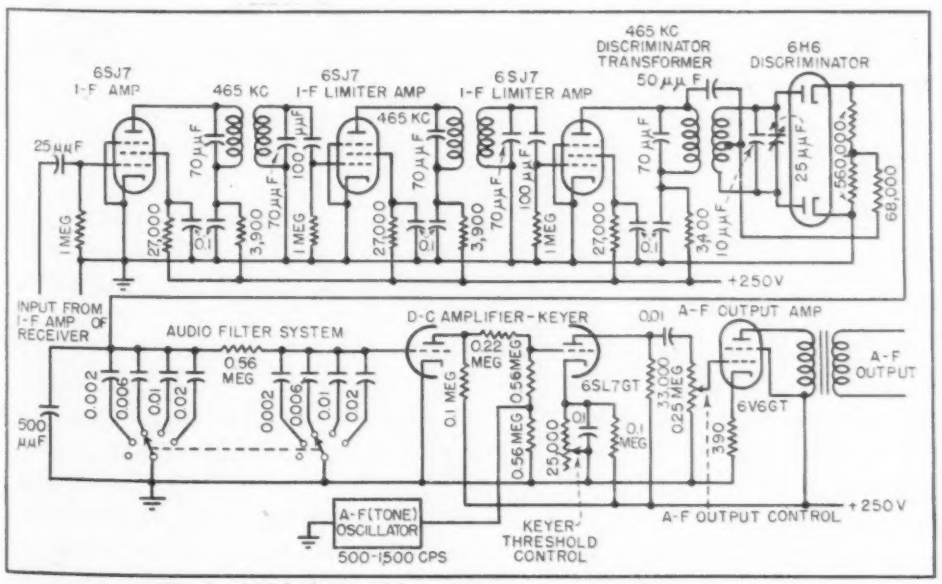

FIG. 23—Discriminator-keyer circuit arrangement for c-w operation

Conclusions

From the overall viewpoint of simplicity, effectiveness, and low distortion, the series-type noise-peak limiter appears to be the best choice for mcw operation, while from the standpoint of effective limiting, minimum change of gain below limiting threshold over a wide threshold range, and relative simplicity, the full-wave a-f shunt output limiter appears best for c-w operation. The former may be combined with the latter for even more effective operation on c-w signals.

It should be remembered that no limiter is a cureall. When noise-peaks do not substantially exceed the desired carrier peak values and occur so frequently that they fill in the modulation, only some of the very elaborate limiter arrangements, such as, for instance, the discriminator-keyer combination types for c-w reception, will afford any considerable degree of relief. Within their inherent limitations, however, those limiters recommended above can be very useful additions to the communication receiver, and also to the broadcast receiver which must work under conditions of high ambient static or similar disturbances.

A PROBLEM in O

Vancouver radio stations, a British Columbia engineering firm, and the RCAF pooled their technical resources to provide audio facilities for the city's 60th anniversary celebration. Placement of microphones to cover a 520 by 125-foot stage and arrangement of speakers to blanket a 525 by 200-foot audience area is discussed

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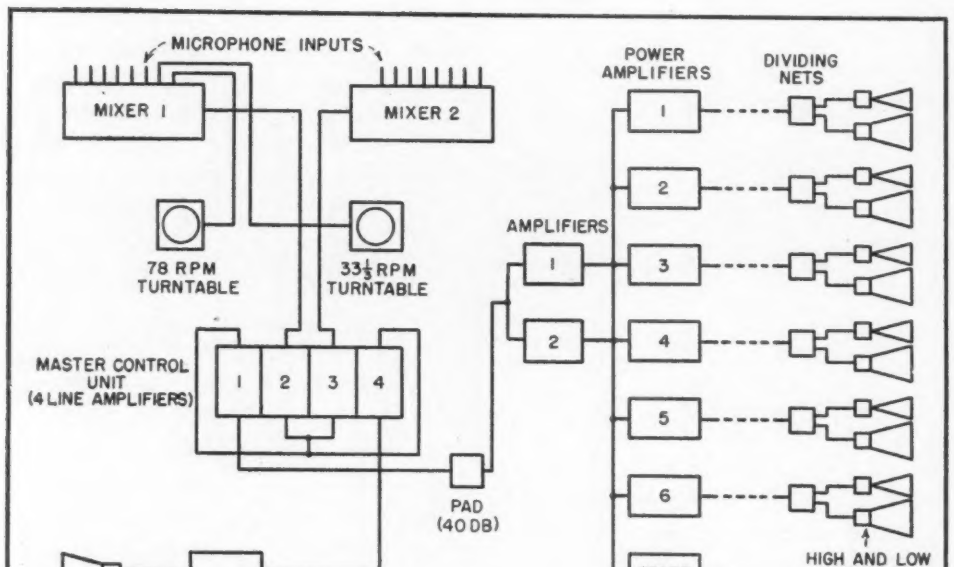


FIG. 1—Block diagram of the complete sound equipment installation

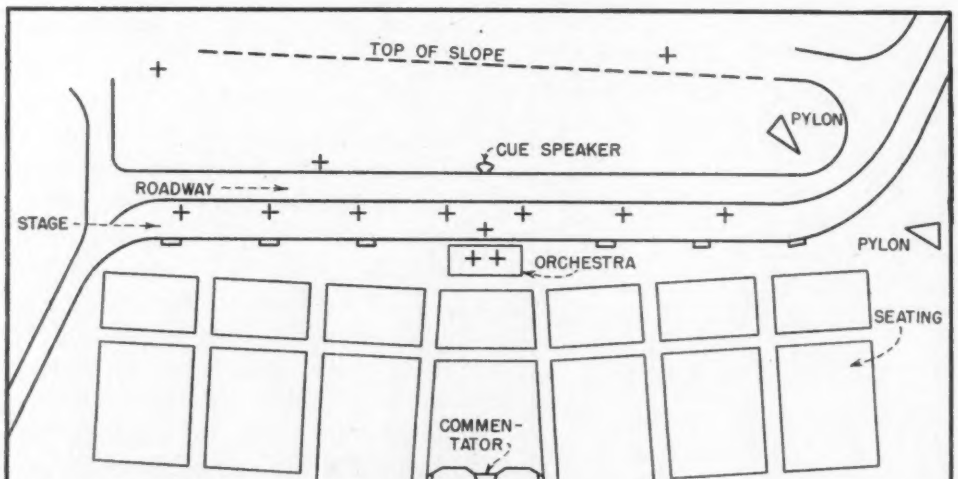


FIG. 2—Plan of the area which was covered, showing the placement of microphones, speakers, and the control tower

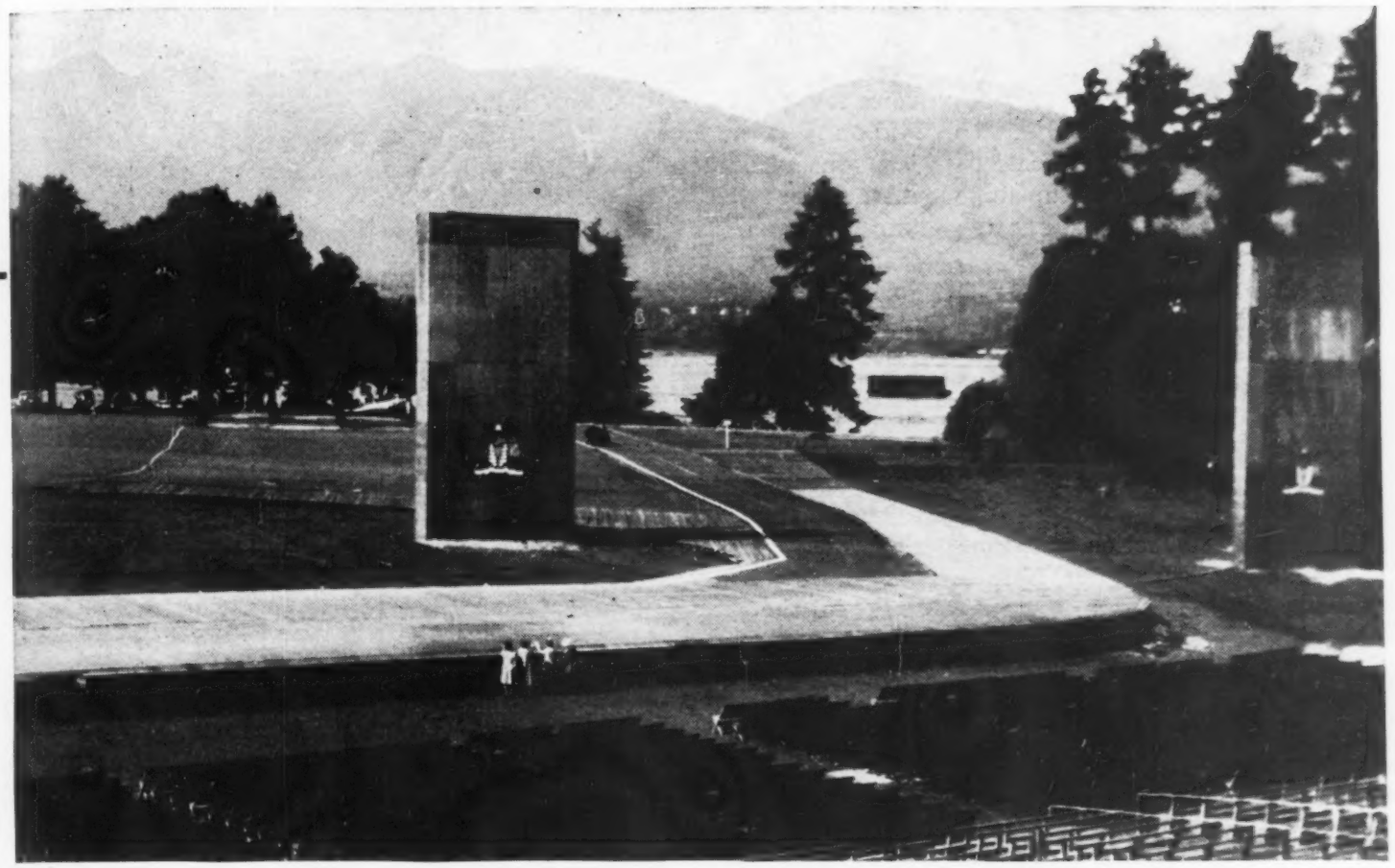
During the summer of 1946, Vancouver celebrated the 60th anniversary of its incorporation. Among many events planned by the citizens' Diamond Jubilee Committee was one which presented a number of interesting technical problems to a group of radio and sound men in the city. This was the Jubilee Show, a presentation of pageantry, which due to its magnitude could only be staged out of doors and yet required treatment similar to that given radio productions in a studio.

It will be the aim of this paper to outline the operations undertaken and to present some of the problems encountered and the solutions evolved, in the hope that it may act as a guide for future enterprises of this type.

Requirements

Study of the blueprints for an outdoor theatre to be constructed at Brockton Point in Stanley Park revealed the unusual extent of the technical facilities which would be required. Microphone coverage would have to be provided for a stage with a frontage of 520 feet. This would include coverage of an upstage area extending along a grass slope behind the stage proper to a depth of 125 feet. Sound projection would have to cover an audience area extending along a 525-foot front to a depth of 200 feet, seating 12,700 persons. The

OUTDOOR SOUND



One corner of the giant outdoor stage, as seen from the roof of the the control tower, and showing the integral road over which heavy equipment taking part in the pageant was moved on and off stage. Figure 2 shows the entire area

requirements clearly indicated that if the desired results were to be obtained, the equipment employed would have to maintain broadcast quality throughout.

The plans were considered by the radio stations of Vancouver with the view of obtaining experienced broadcast technicians to handle the job. The Canadian Broadcasting Corporation's studios arranged to loan one of its experienced program technicians, some sound mixing equipment, and a sound effects multiple turntable unit. Also, through its network operations office, the CBC provided the remainder of the sound mixing equipment and miscellaneous parts.

At this point it was apparent that additional outside help would be required and that someone, giving his full time to the work, would have to be placed in charge of all technical arrangements to coordinate and expedite them. The Royal Canadian Air Force supplied this man in the person of Wing Commander Kenneth Cameron, who was formerly chief engineer of CKRC Winnipeg.

Although sound mixing equipment was available, no adequate sound projection equipment was obtainable in the city. A contract was awarded the Dominion Sound Company when it was found that they could import a sufficient number of large theater projection units with the necessary amplifiers, in addition to 15 microphones.

Equipment

A functional description of the entire system now will be undertaken and the reader is referred to Fig. 1.

Thirteen stage microphones, one commentator's microphone and two turntable units were connected to the inputs of two CBC portable mixers. These provide approximately 90-db gain. The outputs of the two mixer units were fed separately into two of the four line amplifiers in a CBC portable master control unit. The outputs of the two amplifiers receiving feeds from the mixers were coupled together. The other two amplifiers in the control unit were bridged on these to give two isolated, separately controllable feeds of the complete program. One of these feeds was supplied to the sound projection amplifiers and the other was used to feed the monitor system in the control rooms.

Sound projection was accomplished by the use of two Northern Electric R4079A amplifiers feeding seven R4080A power amplifiers. The output of each power amplifier was terminated in a high-frequency dividing network to feed an Altec Lansing type H210 low-frequency horn and a type 288 high-frequency unit. Six of these double projectors were used, leaving one power amplifier as a spare. The sound projectors themselves

were set in the apron of the stage at regular intervals on each side of center stage. The separation of the two center units was increased slightly to allow for placement of pit microphones.

All the microphones used were Western Electric type 639A cardioids. These were used in the cardioid setting on all occasions except one. The extreme up-stage left microphone located on the top of the grass slope was subject to considerable wind sweeping in from the harbor entrance. This microphone was set on the dynamic condition with optimum results.

Turntables were used for sound effects reproduction of domestic and transcribed sequences. One Presto K8 turntable recorder was utilized for 78-rpm reproduction, and one NE 5A unit was used for 16-inch transcriptions at 33⅓-rpm.

Installation

The heaviest job in installation was the laying of microphone and speaker cable. All the mixing equipment was mounted in trunks with removable fronts and backs and could be quickly set up and terminated. The sound projection amplifiers were rack mounted and required a minimum of labor after initial connections had been completed. However, the cable-laying process was another matter.

The blueprints revealed that lines for microphone positions would have to be laid for a total of 5,430 feet in lengths varying from 550 feet to 215 feet. This is illustrated in Fig. 2. The work was accomplished by three men, a jeep and some walkie-talkie equipment. The latter provided invaluable assistance in checking the cables from one location to another over distances which were too great for the voice to carry. The lines were first laid out, cut and labeled. Then the jeep was utilized to haul them to the front of the seating area and into position. Microphone lines then were brought to their labeled positions individually and terminated in junction boxes. Three spare lines were pulled in and terminated at center stage. Due to later production changes and additional facilities required, all of the spares were used.

The final phase of the installation was the laying up to the control tower of the microphone lines and the speaker cables. This was done along a five-foot wide duct. The low-level lines were cabled roughly and kept to one side of the duct, while speaker lines occupied the opposite side. No trouble in isolation was experienced.

The ground system required very careful attention. Rain was a continuous problem throughout both installation and early production periods, making open conductor ends subject to considerable moisture with consequent tendencies towards transmission to ground at audio frequencies. The ultimate success of the system required two of the longer lines used on input positions to be individually ground-staked. In addition, all control room equipment was brought to two ground stakes, two feet apart.

The lighting of an outdoor area of this size from 200 feet, which was the distance from control tower to stage, was rather a large project. About 600 kilowatts was under control, resulting in considerable voltage drop in the power circuits when full lighting load was applied so that voltage regulators were necessary on all audio facilities.

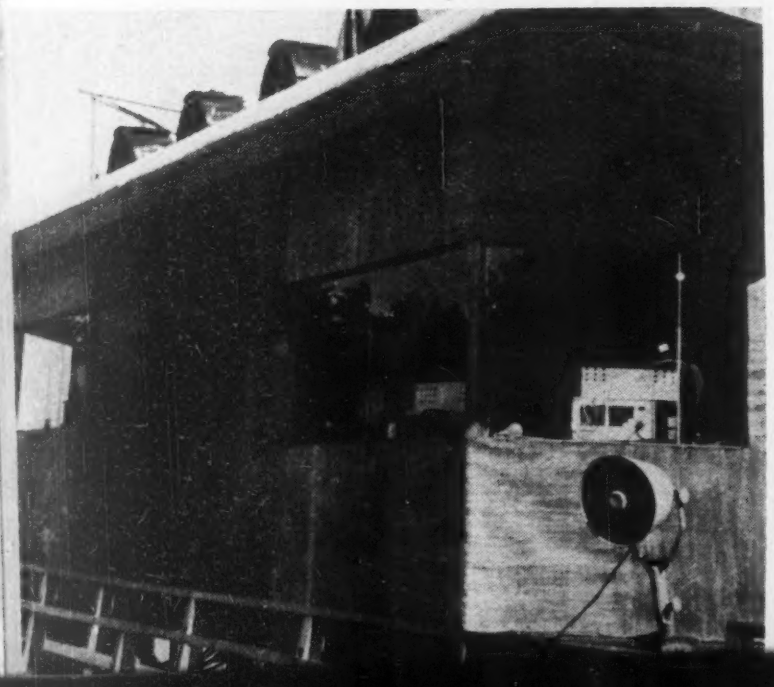
Facilities

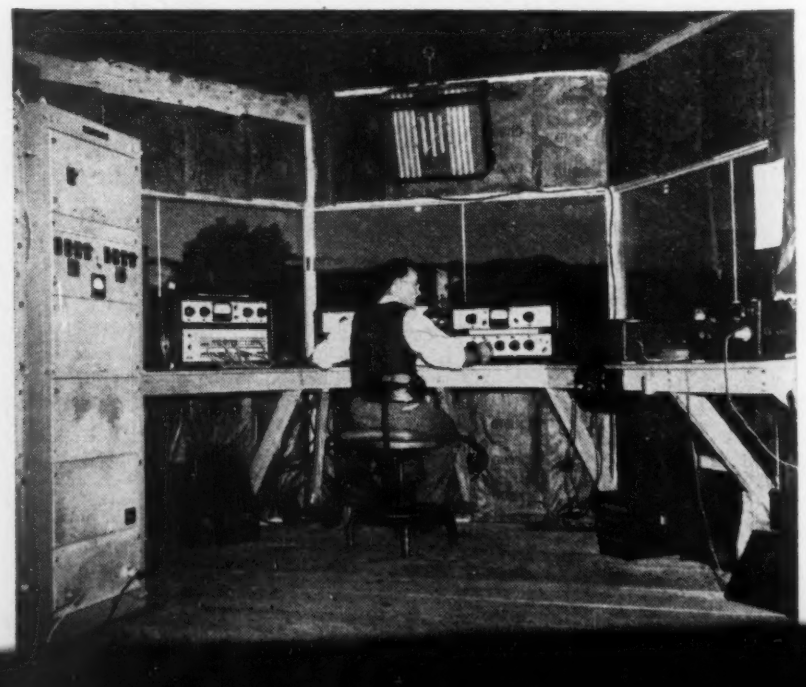
Final plans for the control tower provided for two 15 x 27-ft. control rooms, pictured in Fig. 3. One was to be occupied by the director general and his staff, the lighting control and communications center. The second housed the sound system with the mixers located forward on a shelving along the entire front of the plate glass windows, affording the control operator a view of the entire area. High-level amplifiers were located towards the back of the room to the left of the control position. The recorded sound equipment occupied the right-hand postion of the shelving so that its operator was conveniently close to the program control operator at all times.

A commentator's cubicle, glass fronted, was constructed between the double-bay fronts of the two control rooms. This gave the commentator a wide view of the stage area and direct communication with both director and program operator.

The sound control room was

FIG. 3—(Left) Exterior of the Vancouver Diamond Jubilee show control tower. The far windows enclose the director's room, the near windows are those of the sound control room, and the cubicle between the two rooms was used by a commentator. The speaker (not part of the main sound system) was used to convey directions to the stage. (Right) Interior of the sound control room showing, left to right, one corner of the power amplifier bays, master control unit, the two mixers, and the two turntables





acoustically treated with four inches of rock wool lining, giving excellent dampening and isolation. The monitor speaker was mounted above the control position, giving a good indication to the program and recorded sound effects operators, for balance and cueing purposes.

Operation

The production of the show itself presented a number of interesting situations not envisioned in the original planning. Forty-three hundred persons were involved in the various sequences, opening with the colorful portrayal on stage and across the horizon of the coming of the early explorers and their meeting with the Indians, and continuing through to the parades of civic apparatus and industrial machinery. In these latter scenes considerable trouble was anticipated in the transmission of heavy vibration along the microphone stands.

The roadway along which fifteen-ton log carriers, earth movers and heavy pieces of fire apparatus moved was constructed upstage (see photograph and Fig. 2) and was physically a part of the stage itself. Eighteen-inch square plyboard bases were bolted to the bases of the microphone stands as shown in Fig 4. Two-inch square kelder pads were glued to the four corners of the plywood sub-base, providing sufficient shock absorption to cut the vibration effects to a point where no trouble was experienced.

Another technique illustrated in the figure is the method employed to keep the microphone cable off the stage area, where it would interfere with motor vehicles and dancers moving through the various scenes in the show. Three-inch holes were drilled through the stage and the microphone cable dropped through to the junction boxes directly beneath each position. All cable was thus concealed.

Mention of the dancers brings up one of the most critical of the production problems encountered. This was the inability of the several ballet groups in scenes of the cavalcade of Vancouver's history to hear their orchestral accompaniment. The light intensity, as a result of spotting, was such that the conductor in the pit was almost invisible. The orchestra pit had been constructed directly in front of center stage, but notwithstanding this fact, the open-air absorption prevented the artists hearing the music directly. Also, the highly directional characteristics of the sound projectors made it impracticable to use them as a cueing source.

The ultimate solution of this problem was found in the installation of a horn upstage in the sand packing for the stage roadway. As this road ran parallel to the stage, the horn could be placed at the center stage point and faced upstage. A program feed was provided and a point in level adjustment finally was reached where both artists and technical personnel were satisfied with the results. This was aided by the limited frequency response of the horn, which helped to eliminate feedback.

The orchestral and choral setups, which looked somewhat difficult at first glance, became simplified greatly as the result of a plan which was worked out to yield a minimum of complication. The orchestra was arranged in a conventional layout in the left half of the 50 x 20-foot pit. A choir of sixty voices was set up in the right section facing the orchestra. This permitted the placement of two microphones, on cardioid position, back to back. Maximum isolation coupled with good definition was attained. The changing personnel of the choral group eliminated the possibility of a standard vocal placement. The final arrangement split the group into two sections, male and female, on either side of a narrow aisle. The choral microphone was placed about 15 feet in front of the center of the front line of the choir, and artists always were instructed to project their voices at a point well in front of this location. Again the results were very favorable.

Personnel

It is appropriate to mention and give credit to a group from the Royal Canadian Corps of Signals, who installed and operated a complete seventy-line switchboard to provide telephone communication to all keypoints in the several square miles of production and marshalling area. During the production, a party line setup was worked out whereby the communications director acted as talker to all points in relaying production and technical instructions. The operators in the field spoke only when placing a call or when individually called.

Wing Commander Cameron, Flight Lieutenant Lowman, and James Gilmore set up all sound mixing and control equipment as well as laying the cables and wiring required from microphone to projection amplifier racks. The projection system was installed by Leo Sigurdson, Art Jackson and Ray Winstone. Lieutenant Ralph Hind, Royal Canadian Navy, was in charge of power and lighting equipment, and the operation of stage lighting controls, while Lieutenant Stan Stebban, Royal Canadian Corps of Signals, supervised a group who installed and operated the telephone system.

In program operations, James Gilmore was at the sound mixing controls, with Warrant Officer Rex Thompson, RCCS, assisting with sound effects.

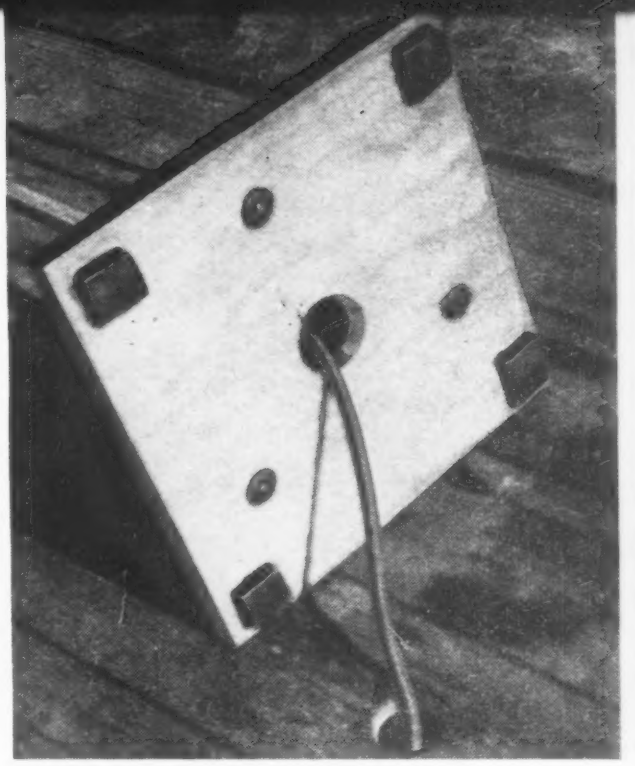


FIG. 4—Closeup of microphone stand base, tilted to show how this wooden base was bolted to the stand itself and shock-insulated, and how cables were carried through the stage floor

Electrometer

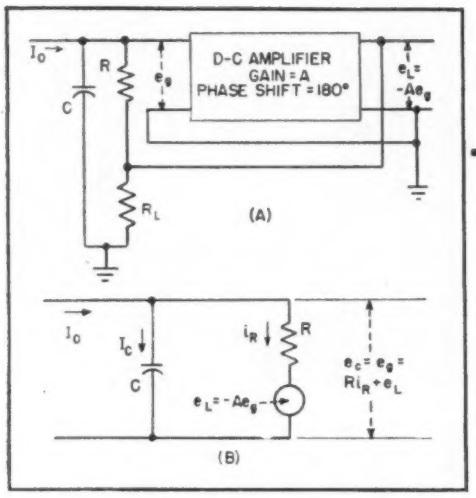


FIG. 1—(A) Basic circuit of high input impedance amplifier, and (B) equivalent circuit

Application of negative feedback to high impedance input circuits of direct-current amplifiers reduces the time constant, thereby increasing the rapidity of response. One such circuit is analyzed, curves are presented, and a typical amplifier is described

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WHEN A DIRECT-CURRENT AMPLIFIER is used to amplify extremely small currents, the high input resistance in conjunction with the inherent input capacitance introduces a large time constant that will not allow the amplifier to respond to rapid changes.

In typical electrometer vacuum tube circuits such as are used to measure ion current in a mass spectrometer tube or an ionization chamber, the input resistor usually is of the order of magnitude of 10^{11} ohms. With an input capacitance of only twenty micromicrofarads this resistance would produce a time constant of two seconds. Hence any rapid variations in ion current would not appear at the output of the amplifier.

Transient Response

The effect of the large time constant can be reduced by using a high gain direct-current amplifier and feeding all of the output voltage back into the input circuit. Partial negative feedback has been used extensively for improving the response of a-c amplifiers. Negative feedback has even greater advantages in the d-c electrometer amplifier. While voltage gain is reduced to unity if the voltage feedback is 100 percent, current gain, linearity, stability, and speed of response are greatly increased. Full negative feedback has the additional advantage, as pointed out by Hipple and Grove[1], of reducing grid swing on the input stage, thus allowing the use of a higher value of input resistor because the grid current can then be held closer to zero.

Consider the feedback amplifier circuit shown in Fig. 1A: C represents the inherent capacitance of the input circuit, R the input resistor, A the gain of the amplifier without feedback, and R_L the resistance of the amplifier output circuit including the load. The voltage e_g actually applied to the amplifier is equal to the difference between the voltage developed across R and the output voltage e_L. Because R_L is usually very small compared to R, a simple equivalent circuit shown in Fig. 1B may be drawn.

If the input current changes abruptly from zero to some value I_0, then the output voltage will rise exponentially to a value

$$e_L = -RI_0 \frac{A}{1+A} \cong RI_0$$

if $A >> 1$

A transient solution of the equivalent circuit shown in Fig. 1B for an abruptly applied current I_0 gives

$$e_L = -RI_0 \left(\frac{A}{1+A}\right)\left(1 - \epsilon^{-\frac{1+A}{RC}t}\right) \quad (1)$$

If $A >> 1$ this equation reduces to

$$e_L = -RI_0 \left(1 - \epsilon^{-\frac{At}{RC}}\right) \quad (2)$$

which shows that the output voltage rises exponentially to the value RI_0. Furthermore, if a time $t = RC/A$ be chosen as the new time constant, designated as T_f, then substituting this value of time in

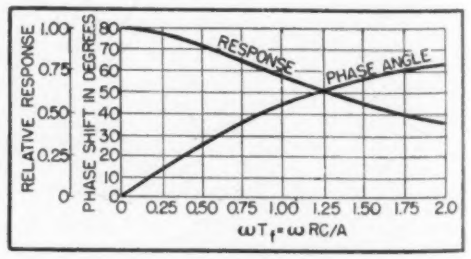

FIG. 2—Normalized transfer characteristic of input circuit

*The investigation on which this paper is based was made while the author was on leave of absence from A. and M. College of Texas to the Westinghouse Research Laboratories.

Input Circuits

Eq. 2 shows that the output voltage e_L will rise to 63.2 percent of its final value in a length of time T_f seconds. Because this percent of rise is the basis for the time constant of a circuit without feedback, then evidently 100 percent negative feedback reduces the time constant of the input circuit by the factor $1/A$.

Frequency Response

It is desirable to determine the frequency response of an electrometer amplifier to an input current that is varying sinusoidally. The input current I_0 may be replaced by the effective value I of a current wave expressed by $i_0 = I_{MAX} \sin \omega t$ and the other currents and voltages shown may also be replaced by effective values: I_C, I_R, E_g, E_C, and E_L. A vector treatment of the equivalent circuit will then give the solution

$$E_L = -IR\left(\frac{1 - j\omega\,(RC/A)}{1 + \omega^2(RC/A)^2}\right) \qquad (3)$$

Letting $(RC/A) = T_f$, the time constant of the input circuit with 100 percent negative feedback, and expressing the complex expression of Eq. 3 in terms of its magnitude and phase angle there results

$$|E_L| = IR\frac{\sqrt{1 + \omega^2 T_f^2}}{1 + \omega^2 T_f^2} \qquad (4)$$

and the phase angle of E_L is $\phi = \tan^{-1}\omega T_f$. The relative response is

$$\frac{E_L}{IR} = \frac{\sqrt{1 + \omega^2 T_f^2}}{1 + \omega^2 T_f^2} \qquad (5)$$

If the relative response and the phase angle are plotted as functions of ωT_f, the resulting response curves are universal curves and can be used to determine the response and phase shift for any given set of circuit constants with very little calculation involved. Such a set of response curves are shown in Fig. 2. Note that for the value of $\omega T_f = 1$ the response is down to 0.707 of its zero frequency value and the phase shift is 45 degrees.

Practical Application

In the development of the above equations it was assumed that the d-c amplifier itself had reasonably high gain and that its phase-shift (other than the 180 degrees required for negative feedback) was negligible compared to that of the high-resistance input circuit. Furthermore, the distributed capacitance of the input resistor was neglected. These conditions are not difficult to attain in actual practice but it should be kept in mind that at some higher frequency the total phase-shift around the circuit may produce positive feedback and consequent oscillations.[2] Theory and practice both indicate that this undesirable condition can be eliminated by putting a low-pass filter across one of the stages of the amplifier. Simply connecting a capacitor of the proper value from the plate of one of the stages to ground will usually accomplish the desired result.

It is also desirable to design the complete amplifier so that high gain is realized in one of the early stages, preferably, the first. This design makes the feedback more effective for reducing drift. Where the input resistance is of the order of 10^8 to 10^{11} ohms, the input stage must necessarily be of the electrometer type which usually has a voltage gain of less than one, but satisfactory results have been obtained by making the following stage of very high gain.

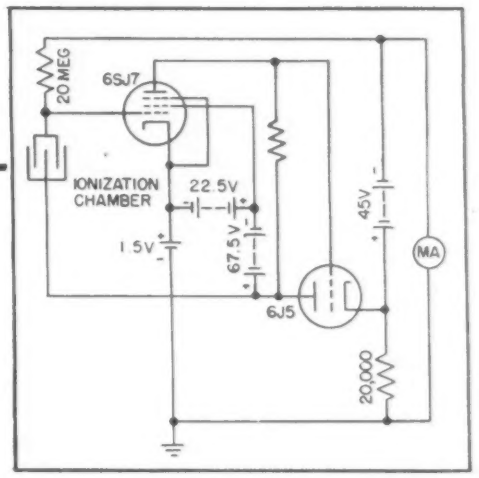

FIG. 3—Essentials of typical electrometer amplifier, illustrating methods of applying negative feedback

In Fig. 3 is shown a typical electrometer amplifier circuit using the above principles. This very simple amplifier was used to amplify the ion current from a multiple-plate ionization chamber which had an inherent capacitance of approximately 0.01 microfarad. Without feedback the time constant of the input circuit was 0.2 seconds, which gives a response that drops off to 0.707 at a frequency of $f = 1/2\pi T = 0.8$ cps. In this amplifier the first stage had a gain of 75 and the cathode-follower output stage had nearly unity gain, so that with feedback the time constant became $T_f = RC/A = 0.2/75 = 0.00267$ second, and the reduction of response to 0.707 takes place at about 60 cps. Experimental response curves taken on this amplifier verified the above results. The output cathode follower stage serves not only as a low-impedance source for driving a recorder or meter but also reduces the bucking potential required to bring the output back to ground level[3].

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(1) Private communication.
(2) Peterson, E., Kreer, J. G. and Ware, L. A., Regeneration Theory and Experiment, *Proc. I.R.E.*, p 1191, October 1934.
(3) Hipple, J. A., Grove, D. J. and Hickam, D. J., Mass Spectrometer, *Electrical Engineering*, p 141, April 1945.

APERTURES in CAVITIES

Size and placement of apertures and slots in walls of resonators affect loading, internal field distortion, and efficiency of energy transfer from cavity to load. Experimental results indicate effects of opening size for wanted and unwanted radiation

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ELECTROMAGNETIC energy, when generated in a cavity by a beam of electrons, has to be guided out of the cavity and into a load. To extract energy a loop can be coupled to the internal magnetic field. Another method is to project the end of either a tuned or terminated transmission line into the internal electric field. But probably the neatest way, and the one which is perhaps the most likely to be used for most engineering purposes, is that of cutting an aperture in the wall of the resonant cavity at an appropriate place. Energy will travel out through such an aperture to a greater or lesser degree, and with differing radiation patterns according to position, size, and shape of the aperture in relation to the mode of oscillation within the cavity.

Slots and Apertures

Typical experimental results indicate the operation of this latter method. A rectangular resonator shown in Fig. 1A and having the dimensions $x = z = 59.8$ cm, and $y = 15.0$ cm was set into oscillation at its lowest frequency (H_{011} mode; subscripts here indicate the number of standing waves in each of the three cavity dimensions). Under this condition the electric field was wholly in the y direction. The current antinode was around the vertical sides of the box; the voltage antinode was in the center of the x-z sides. The measured resonant wavelength was 81.8 cm.

A slot a-b was cut as shown so that dimension b was normal to the lines of current flow. Dimension a was 1.5 cm. The slot dimension b was varied from zero (no slot) to 20 cm. The Q of the cavity varied with b in the manner shown in Fig. 2A. Wavelength remained almost constant, increasing only to 82.3 cm as b was increased to 20 cm. The electric field

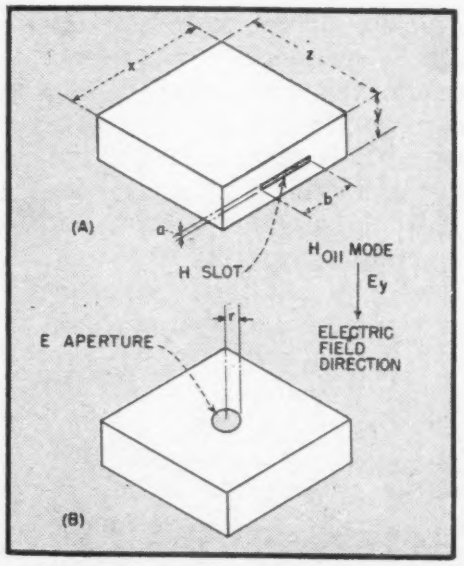


FIG. 1—Openings in cavity serve to extract electromagnetic energy

shape within the resonator is very little affected over this range of dimension b.

A slot at the current antinode operates by virtue of disturbing the magnetic field at the wall of the resonator, and is therefore referred to an H slot.

Instead of using an H slot at the current antinode, electromagnetic energy can be withdrawn through an aperture positioned at the electric antinode. This hole in the cavity wall is called an E aperture. Such an arrangement is illustrated in Fig. 1B.

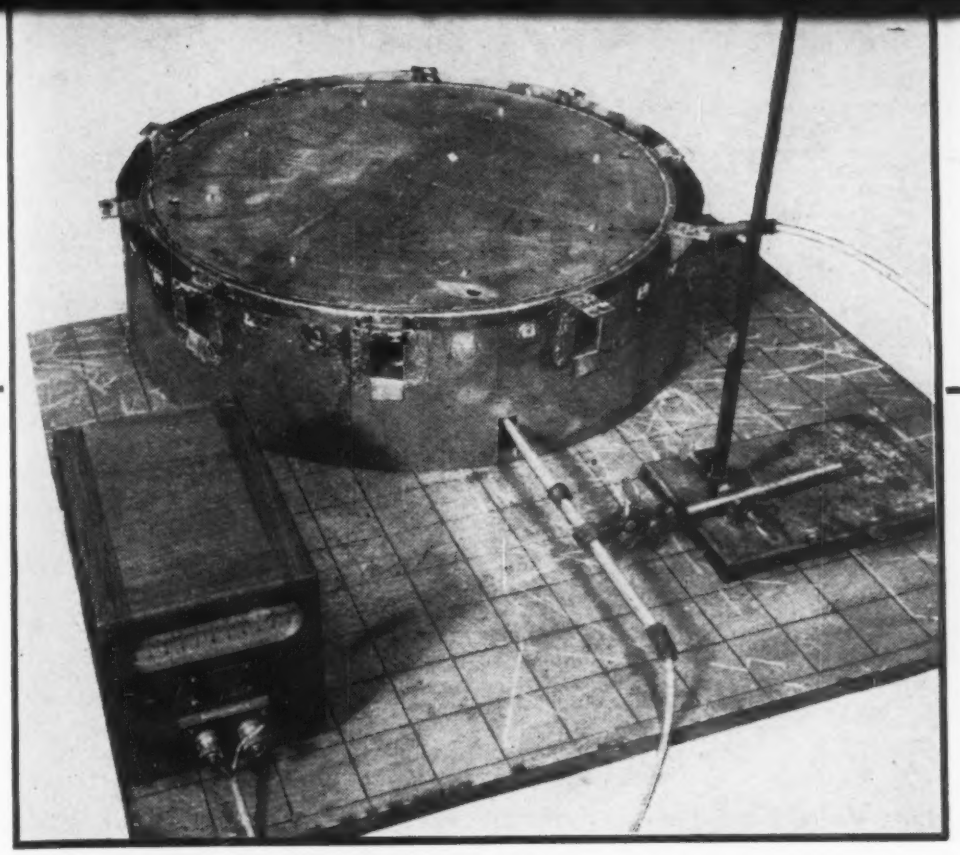
An experimental curve of the Q of the same resonator as used with the H slot, but with an E aperture used instead, is also plotted in Fig. 2A. It was found that if the diameter of this aperture was increased much beyond three or four centimeters the electric field was severely distorted.

In most resonators used in conjunction with electron beams, the electrons are injected at the electric antinode and it is necessary, as far as possible, to preserve a fairly even distribution of electric field in that neighborhood. Moreover, it is generally convenient to separate the point at which the electron beam enters the resonator and the place where the electromagnetic energy is withdrawn. Therefore the H slot is generally the more useful of the two methods of loading the cavity. For this reason the plot of E aperture in Fig. 2A has not been carried to larger diameters.

Loading Factors

In any resonator the maximum instantaneous value of the energy stored in the field is given in mks units by

$$W_F = \frac{\epsilon_0}{2} \int E^2 dv \qquad (1)$$



Laboratory measurement of loading of cylindrical resonator with circumferential openings intermediate between slots and apertures

where ϵ_0 is the specific inductance-capacitance of free space, E is the maximum instantaneous value of electric field in the cavity, and v is the volume of the resonator. The selectivity factor of the resonator is:

$$Q = \frac{\omega W_F}{P_R} \qquad (2)$$

where $\omega = 2\pi C/\lambda$, C being the velocity of the electromagnetic wave and λ the electromagnetic wavelength, and P_R is the power lost in the internal surface of the resonator.

If a load is added in which power P_L is dissipated, the selectivity factor becomes

$$Q_L = \frac{\omega W_F}{P_R + P_L} \qquad (3)$$

which can be rewritten as

$$\frac{1}{Q_L} = \frac{P_R}{\omega W_F} + \frac{P_L}{\omega W_F} \qquad (4)$$

or

$$\frac{1}{Q_L} = \frac{1}{Q} + K_1 \qquad (5)$$

where K_1 may be referred to as the aperture loading factor.

From the measurements presented in Fig. 2A we see that the Q of the unloaded cavity is 13,700. The load Q when loaded can be obtained from these curves. Using Eq. 5 the respective loading factors can be plotted for the H slot or the E aperture used in this resonator at the H_{011} mode. Aperture loading is plotted in Fig. 2B for both cases. Further studies show that dimension a of the slot has comparatively little effect upon the loading.

Coupling to a Resonant Load

The loading factor K_1 applies only when the aperture is radiating into free space. If instead the slot is arranged to couple the resonator to another tuned element, the phenomenon will be modified in a more or less complicated way depending upon the relative damping of the two resonators and the coefficient of coupling. If, as will be described later, a dipole aerial, which is tuned to the resonant wavelength, is arranged with its current point near the H slot or one of its voltage points in the E aperture, the loading factor will increase very much more rapidly with either b or r than is indicated in Fig. 2B. This phenomenon enables much smaller

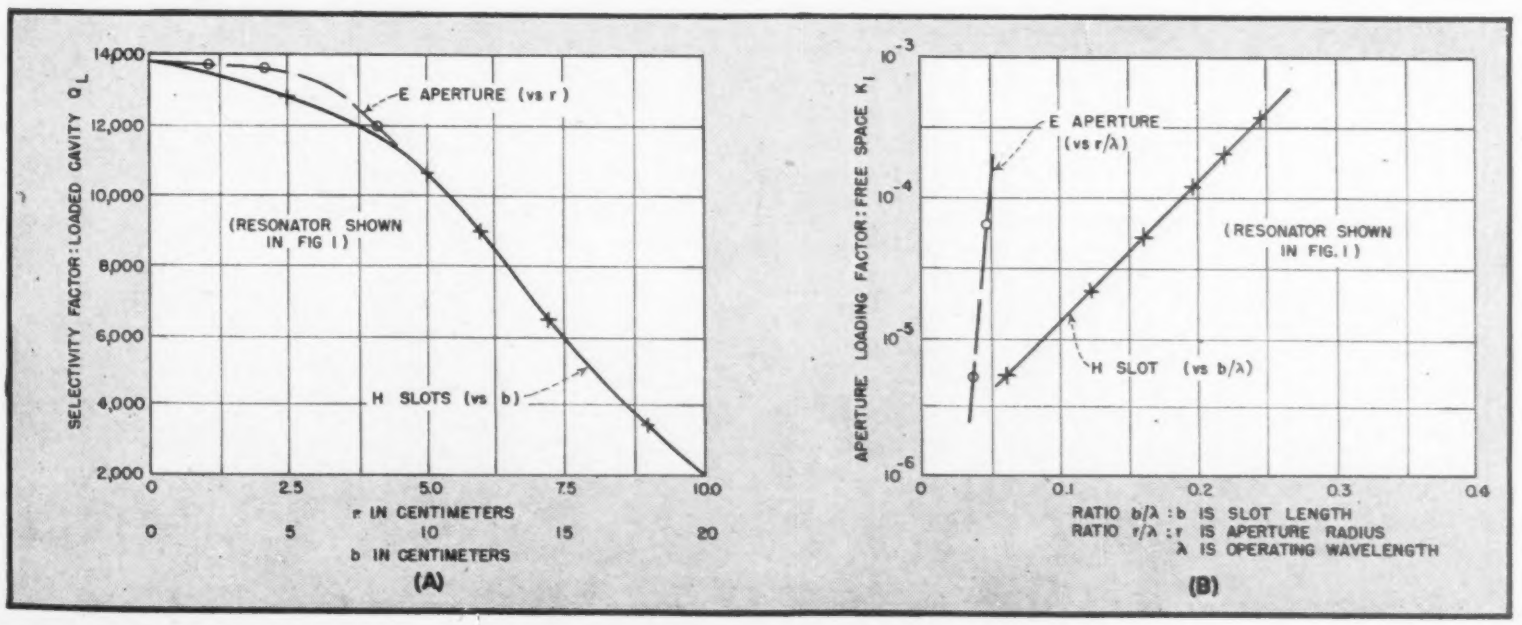


FIG. 2—Loading is affected by size of opening in resonator

values of b or r to be used for a given loading, and correspondingly less disturbance of the internal field shapes within the resonator is produced.

It can be shown that the efficiency of a resonator and load in combination is given by

$$\eta = \frac{P_L}{P_L + P_R} = 1 - \frac{Q_L}{Q} \qquad (6)$$

from which it follows that Q_L/Q should be roughly not more than one-tenth.

Unintentional energy leakage through apertures must also be considered. It is often necessary not only so to arrange an aperture that considerable energy is guided from the cavity, but in addition to arrange other apertures through which electrons may be injected into or removed from the cavity, so that they do not allow appreciable energy to leak out.

If we indicate by K_2 the loading factor of a slot through which energy must not be appreciably radiated from the cavity, we can write for the reciprocal of the selectivity factor

$$\frac{1}{Q_x} = \frac{1}{Q_L} + K_2 \qquad (7)$$

where, as before, Q_L is the selectivity factor of the loaded cavity, and Q_x is the selectivity factor of the cavity losing energy both to a load and by leakage.

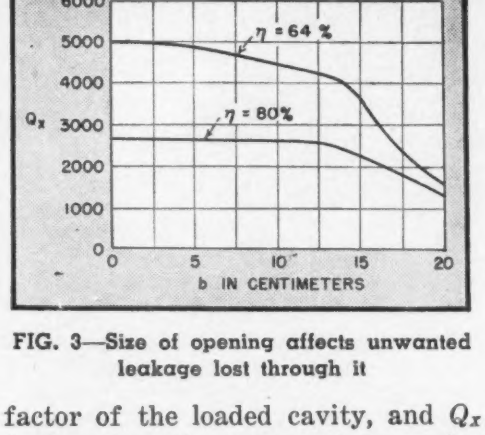


FIG. 3—Size of opening affects unwanted leakage lost through it

To avoid leakage of energy, the value of either b or r must be such that Q_x tends to equal Q_L, so that K_2 is small compared to $1/Q_L$. It will be observed in Fig. 2B that this condition can be met quite readily in practice. However the accidental presence of an external resonant structure might easily upset these conditions.

Figure 3 shows the variation of Q_x with the slot dimension b in the resonator of Fig. 1A. Two cases are shown, one when the resonator is so loaded that $\eta = 64\%$, the other when $\eta = 80\%$. In the latter case an H slot length of 10 cm can be used, for example, to inject electrons without permitting appreciable radiation loss.

Tuned Loads

Consider again the design of an aperture for withdrawing wave energy from a resonator. One of the factors that has to be taken into account is whether the distortion of the internal electric field caused by the aperture in the cavity wall is sufficiently small to be tolerable. The following experimental results illustrate this point.

A roughly cylindrical resonator was arranged to operate in the H_{111} mode on about a 78 cm wavelength. An H slot was cut in one of the flat ends, and Q and Q_L as functions of b were measured. The ratio between electric field magnitudes at two points, each near one of the two flat ends of the resonator, was also measured as a function of b as an indication of the disturbance of the field by the slot.

Utilizing Eq. 5, the resonator load efficiency was plotted together with a curve of the internal field ratio as shown in Fig. 4A. It will be observed that the field became severely distorted when the slot was made suf-

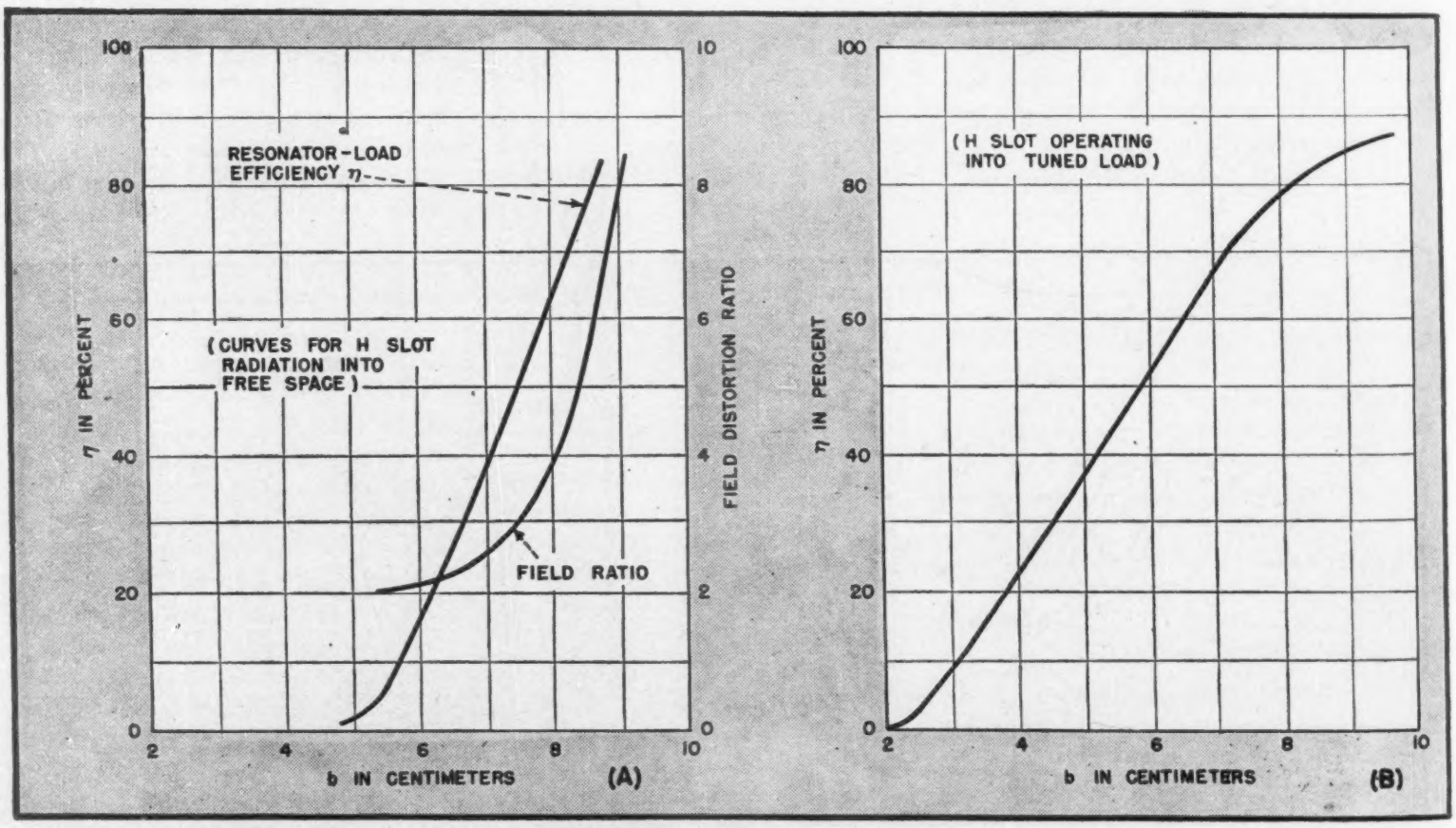


FIG. 4—Energy transfer to the load varies with size of opening

ficiently large to give reasonable efficiency. This trend is largely because the unloaded Q was only 2,000. Had it been higher, a lesser value of b would have sufficed to give a good efficiency.

In this experiment the walls of the resonator consisted of copper foil about 0.01 inch thick. The wall near the slot was next thickened to about six inches, whereupon no appreciable radiation from the resonator to free space was observed even with b at its maximum of ten inches.

The current antinode of a dipole that was tuned to the operating wavelength was next placed near the slot. Adequate energy could then be withdrawn to give good values of resonator-load efficiency, and negligible distortion of the internal field of the resonator was observed. The graph of resonator-load efficiency against b under these circumstances is given in Fig. 4B.

The tip of a tuned dipole was exposed to the field immediately outside an E aperture of such a resonator as that illustrated in Fig. 1B operating in the H_{011} mode. Very small loading was produced unless the aperture was made so large as to distort the field of the cavity. It is in general necessary to insert the dipole or tuned rod a considerable distance into the resonator, or even to connect it to the internal wall opposite the aperture to obtain reasonable resonator-load efficiency.

Hybrid Slots

Some slots are intermediate between the E aperture and the H slot. An example of the use of such a hybrid slot is of interest. It is placed between points of magnetic and electric antinodes of the resonator.

A cylindrical resonator that is depicted elsewhere in this article and whose dimensions are given in Fig. 5 was operated in the E_{010} mode—that is, with the electric field in the axial direction. A circumferential slot was arranged as shown, and bridges were provided to join the center of the flat upper side to the vertical sides of the cylinder. The flat side was 2.5 cm thick.

With 20 bridges, Q_L closely approached Q, the unloaded Q value, which equaled 1,000. With only ten bridges, as illustrated, Q_L dropped to 630. With only two bridges, which

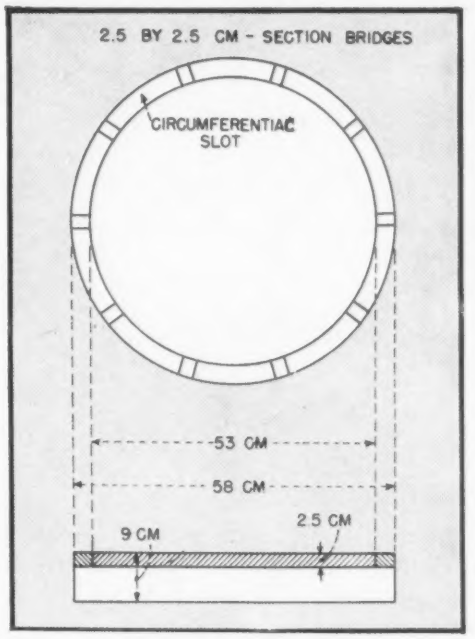


FIG. 5—Cavity used to study coupling to cylindrical resonators

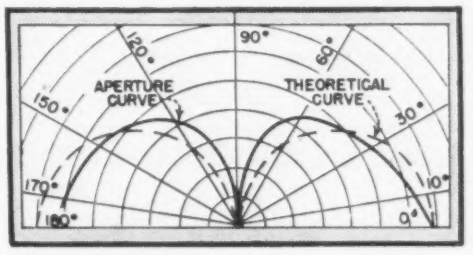


FIG. 6—Neyman compared the patterns of an aperture and a theoretical dipole

were positioned at opposite ends of a diameter, Q_L was reduced to 200. With ten bridges, the thickness of the top was increased from 2.5 to 5.0 cm, and the height of the sides and the thickness of the bridges increased the same amount. However Q_L was unchanged, within the accuracy of measurement, from the previous 630. These results are applicable to the problem of coupling a circular wave guide to a cylindrical resonator.

Because a resonator designed for practical engineering applications seldom leads to analytically tractable shapes, the design of apertures seems to be performed best by experiment, and usually on model resonators the results of which can be scaled down to apply to the operative wavelength. Once the general phenomenon is understood, it is easy to produce desired degrees of loading by trial, with little error.

There does not seem to be an adequate published mathematical analysis of the properties of apertures, although an interesting paper by Neyman has been published in Russian (*Izvestiya Elektroprom. Slab. Toka*, 1940, No. 6, pp 1-16) which provides an admittedly approximate theory and quotes some experimental results.

Aperture Theory

It is not within the scope of this paper to deal with mathematical theory of apertures, but the following comments on Neyman's paper may be of interest.

Neyman points out that a rigorous solution of the problem presents mathematical difficulties. He therefore presents an approximate solution for the E aperture, for which he gives experimental confirmation.

He concludes that the radiation resistance into free space of an E aperture situated at the electric antinode and having a radius r, small compared to the wavelength, is approximately $10^3(r/\lambda)^6$. This radiation resistance is referred to the maximum current in a cylindrical resonator operating in the E_{010} mode.

He also states that performance of an H aperture can be represented by a system of equivalent dipoles for which he derives formulas, but there does not seem to be experimental confirmation of these results nor of the statement that, for b equal r, the radiation from an E aperture is thousands of times greater than that from an H slot. He also presents an expression for power radiated by an H slot which varies as b^6 and a^2. This result does not seem to be confirmed by this reviewer's experiments.

Neyman points out that loading can be increased by external tuned elements such as the dipole, or by resonance of the external surroundings of the resonator or of its own external contours. He also points out that radiation patterns can be produced that are the resultant of the fields from several slots.

The radiation pattern from an E aperture at the electric antinode is similar to that of a dipole. Neyman has shown this to be the case experimentally by the plot shown in Fig. 6.

The present author expresses his thanks to Rediffusion Ltd., at whose Electronics Department the experiments were performed, for permission to publish this paper.

Linear Sweep Circuits

Eight methods of correcting nonlinearity in sawtooth sweep-generating circuits for cathode-ray tubes are presented and analyzed, with 60-cycle circuits as examples

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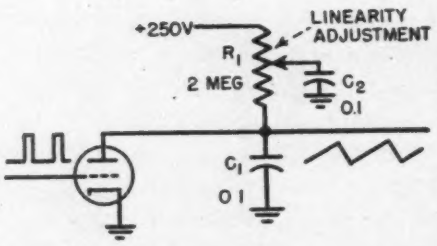
California Institute of Technology
Pasadena, California

THE CONTINUING REFINEMENT of cathode-ray equipment, particularly for television, has made necessary the generation of almost perfectly linear sweeps. These are most easily obtained by the application of some form of linearity correction to the more or less exponential output of a conventional sweep circuit. Several of the more practicable and effective methods of correcting nonlinearity have been selected for description here, although there are many others that may be equally valuable in a particular application.

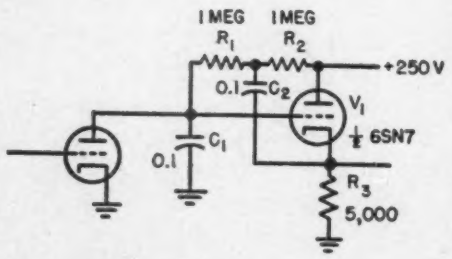
The sawtooth waveform of both electrostatic and low-frequency electromagnetic sweeps is almost invariably derived from the charging or discharging of a capacitance through a resistance. The resistance may be that of a simple fixed or variable resistor, or the plate resistance of a so-called constant-current pentode. In either case the rise or fall of voltage will be exponential, for the plate current of an uncompensated constant-current tube is never absolutely independent of the plate voltage. In the case of a variable-frequency circuit the sweep range is determined by the size of charging capacitor, and a fine adjustment of frequency is provided by variation of the charging resistor or of the grid or screen potential of a constant-current pentode.

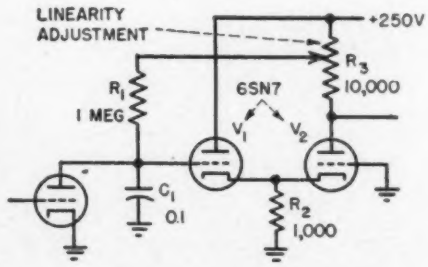
Discharge of the capacitor after



METHOD 1—The simplest means of attaining linearity correction in a fixed frequency sweep is to bypass part of the charging resistor with a capacitor. This gives two *RC* circuits in cascade, which, if it were not for the loading effect of the second upon the first, would result in a perfectly linear output when the two time-constants are equal. In practice, linearity can be definitely improved. The best value of C_2 should be determined experimentally. Input and output waveforms shown here apply to all methods covered

METHOD 2—This circuit, sometimes known as a bootstrap circuit, has been widely used. The sawtooth is fed back through a cathode-follower, which has a gain of approximately one and does not reverse the phase, to the top of charging resistor R_1. In this way a constant voltage is maintained across R_1 and a constant current into C_1. The isolating resistor R_2 may be replaced by a diode, but this is usually of little advantage. As a cathode-follower output is often required after a sweep generator, use of this circuit does not necessarily mean the inclusion of an extra tube. The circuit is especially suitable for use with high-speed sweeps. R_1 and C_1 may be varied without affecting linearity. Almost perfect linearity may often be obtained, although over-compensation is not possible except where constants are such that the combination of R_2 and C_2 acts as in Method 1

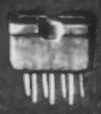




METHOD 3—As in the preceding method, correction is accomplished here by feeding back without phase reversal to the top of the charging resistor. Output is linear when the gain around the feedback loop (from lower end to upper end of R_1) is one, and over-compensation will result as the arm of the linearity adjustment potentiometer is advanced toward the plate of V_2. It should be noted that if a load resistor equal to R_3 is added in the plate circuit of V_1 these two tubes can function as a balanced output amplifier. This method is one of the best available for compensating low and medium-frequency sweeps, either fixed or variable

No. 11953

No. 11955



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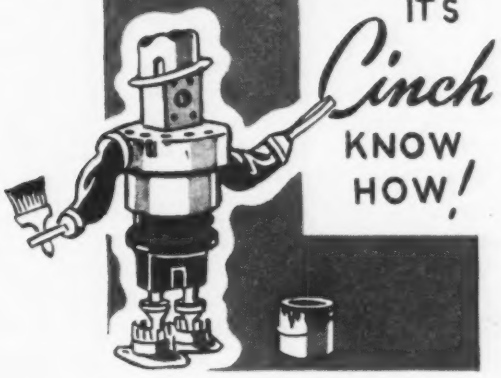

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LINEAR SWEEP CIRCUITS

it has charged (or recharge after it has discharged) is accomplished by means of a thyratron or, in more modern circuits, by an ordinary triode, the grid of which is periodically pulsed from cutoff to near zero bias.

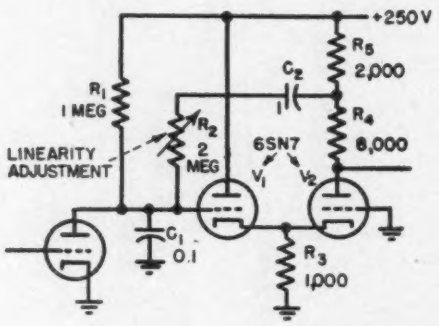
In the data given here the charging resistor and capacitor will be designated R_1 and C_1, respectively, and the discharge (or recharge) will be assumed taken care of by an externally controlled triode. All the methods mentioned are applicable to single or driven sweeps as well as to continuous sweeps. The circuits are shown in their most elementary form, and approximate component values for a 60-cycle sweep are given. Many modifications of each are possible. Adaptation to the particular sweep circuit in use will be necessary.

Most of the circuits discussed here are in actual use, and are covered by U. S. or British patents. Methods 4 and 7 were developed by the writer while a member of the staff of Allen B. DuMont Laboratories, Inc.

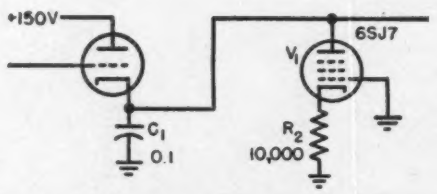
References

(1) Puckle, O. S., "Time Bases", John Wiley & Sons, Inc., New York, 1943.

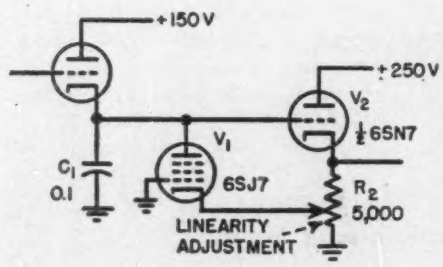
(2) Clarke, A. C., Linearity Circuits, *Wireless Engineer*, June, 1944. (The analysis of Method 6 in this reference is incorrect, as it disregards the fact that the signal fed back to the pentode cathode appears between cathode and control grid.)



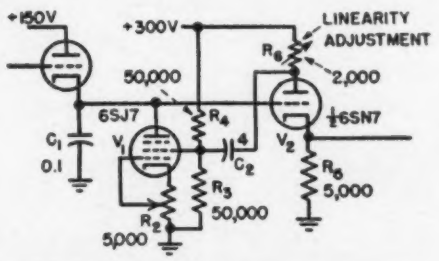
METHOD 4—This circuit is a modification of Method 3 which is useful under certain conditions. Although slightly more complicated, it has the advantage that the linearity-adjusting potentiometer is not the load resistor of V_2. Perfect linearity will result when the ratio of R_2 to R_1 is equal to $A-1$, where A is the gain around the feedback loop



METHOD 5—The output of almost any type of sweep generator can be improved by replacing the charging resistor with a constant-current pentode, but this is easily done only where the capacitor discharges, rather than charges, through the resistor. A pentode having a high plate resistance should be used, and the tube should be operated well out on the flat portion of the characteristic. The screen potential must of course be held constant, as by a fairly heavy bleeder between the positive supply and ground. Constancy of plate current will be much improved by a large cathode resistor, the effective plate resistance being increased by a factor of $1-G_mR_2$

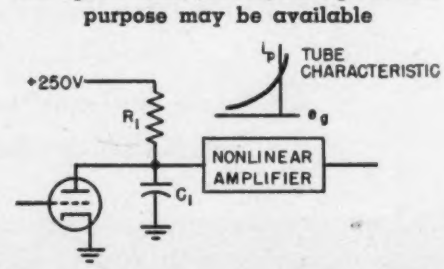


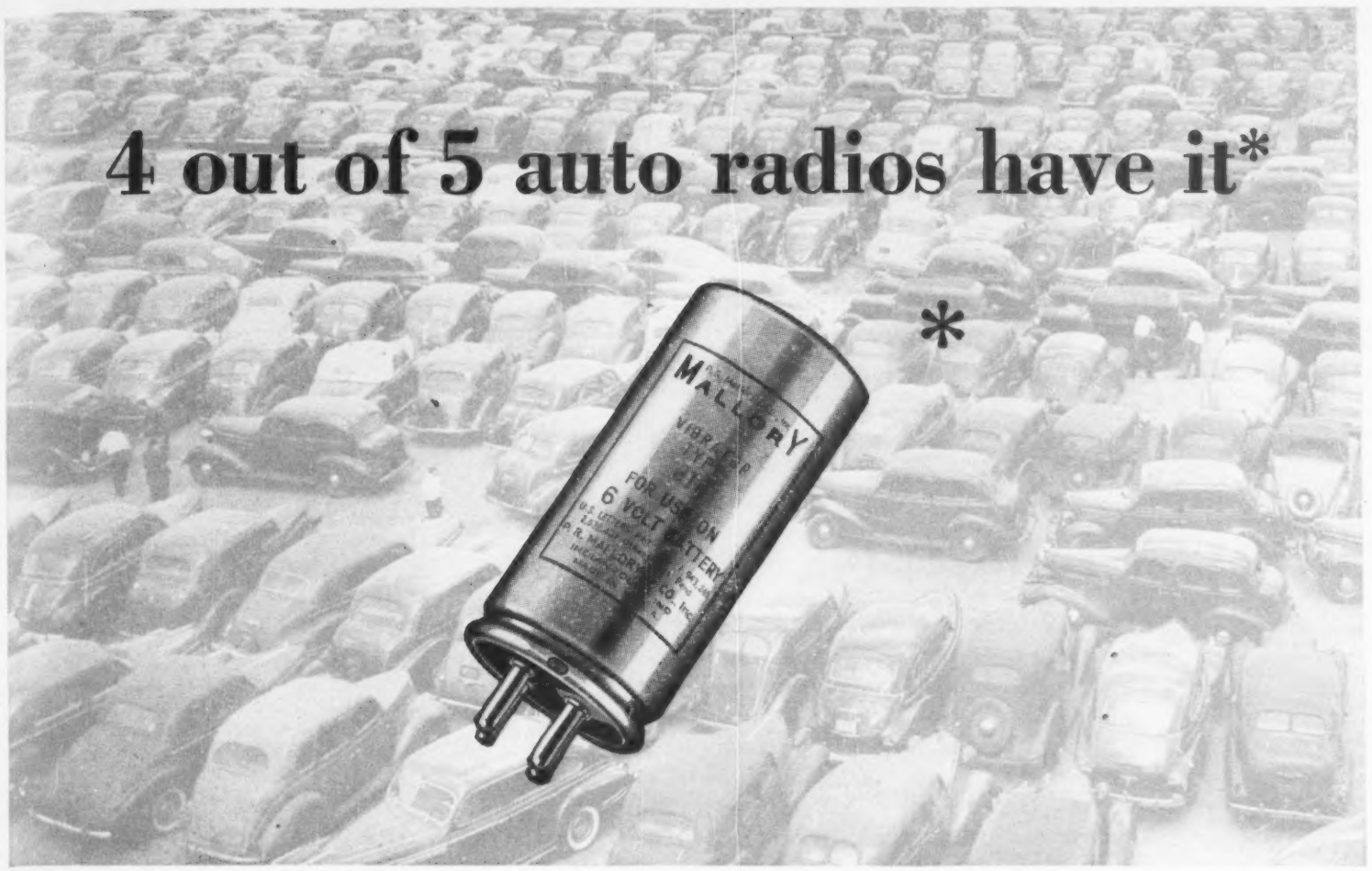
METHOD 6—The use of a constant-current tube may improve linearity though it will never make possible a perfect sawtooth, but by the additional application of feedback even strong overcorrection can be attained. This method utilizes the cathode-follower which often follows such circuits to feed a small part of the output voltage back to the cathode of the constant-current pentode. The circuit is useful both for high-speed sweeps and, because it is direct-coupled, for those of extremely low frequency



METHOD 7—The preceding method can not easily be applied to some sweep circuits because of their use of cathode degeneration for frequency control. In this case feedback can be to the pentode screen, with equally good results. A variable resistor, R_6, can be inserted in the plate circuit of the cathode-follower with little effect on the output, if it is small compared with the plate resistance of the tube. The screen supply bleeder R_4 and R_5 may be omitted and the screen connected directly to the plate of the cathode-follower instead of through C_2 if operating voltages permit

METHOD 8—Vacuum tubes are not linear devices, in that their e_g-i_p characteristics are seldom straight lines. With careful design, advantage can be taken of this curvature to counteract imperfections of the sawtooth. This is done in many magnetic sweep circuits, with a bias control on the output stage as the linearity adjustment. At present, ordinary tubes are capable of giving definite improvement. In the future, special types designed especially for this purpose may be available





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TUBES AT WORK

Edited by VIN ZELUFF

All-Electronic Color Television 140
New Uses for Pentagrids 142
Direct-Coupled R-F Amplifier 154
Multiple Thyratron Circuits 158
High-Fidelity Phonograph 178
Radar-Guided Bomb 186

All-Electronic Color Television

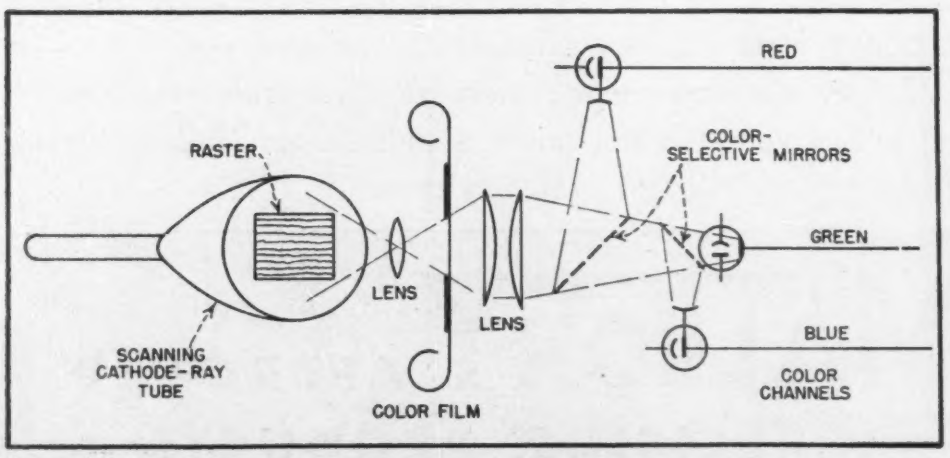
LONG AWAITED by radio engineers, an electronic color television system has been demonstrated publicly by RCA Laboratories. Color slides and a color movie cartoon were transmitted over coaxial cable and were shown on two laboratory receivers and, in black and white, on a current production television receiver.

The electronic system makes use of simultaneous color transmission instead of sequential color-by-color transmission used in the mechanical systems. In the simultaneous system, a cathode-ray tube is used as the light source for illuminating the color film or slide. On the face of this tube the scanning beam forms a conventional 525-line raster.

Light from the raster shines through the film and is focused into a color-selective mirror arrangement that splits the image into three parts, red, green and blue. Two half-mirrors allow the green image to proceed to a phototube where it is converted into a signal for the green image channel. At the same time, they deflect the red and blue images into their respective phototubes that feed two other signal channels.

The color transmission was made over three coaxial cables, one for each image, from a transmitter in the Laboratory building.

The color receiver is equipped with three 3-inch projection-type cathode-ray tubes which are separately actuated by the signals from the red, blue, and green signal channels. The trio of kinescopes is called a Trinoscope. The three color images from the tubes are optically projected into a composite picture on a 15 x 20-inch screen to form the full-color picture.



At the transmitter, the raster is formed on the face of the cathode-ray tube at the left, and light from this is focused by the lens on the color film or slide. The colored image is then split by the color-selective mirrors into three parts—red, green, and blue—for actuating the phototubes feeding the three signal channels

Color slide television camera that uses a 30-kv cathode-ray tube as the light source. Ray D. Kell, head of television research at RCA Laboratories, checks the tube by looking through a glass window in the top of the case

The electrical characteristics of the green-image signal, including the synchronizing pulses, are identical to those of the present black-and-white standards so that broadcasts from color stations using the electronic simultaneous system can be received on a current production black-and-white receiver by addition of a radio-frequency converter that tunes from 480 to 920 mc, the range now allotted to experimental television broadcasts, including color. The simultaneous transmission of the three color channels requires a bandwidth of 16 to 18 megacycles.

With the converter, present-day television sets could receive color programs and reproduce them in black and white by using the green-image signal. Thus, existing receivers would not be made obsolete by the introduction of color at some future date. Even a prewar television receiver could be adapted to tune to the electronic color transmission and use the green-image signal to show pictures in black and white.

Conversely, it will be possible for electronic color television sets to receive the broadcasts of black-and-white stations. This was demonstrated by showing a black-and-white broadcast from New York, 45 miles away, on all three receiv-

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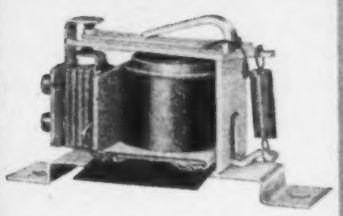
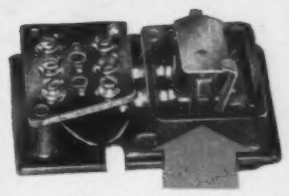


GUARDIAN'S SERIES 120 RELAY

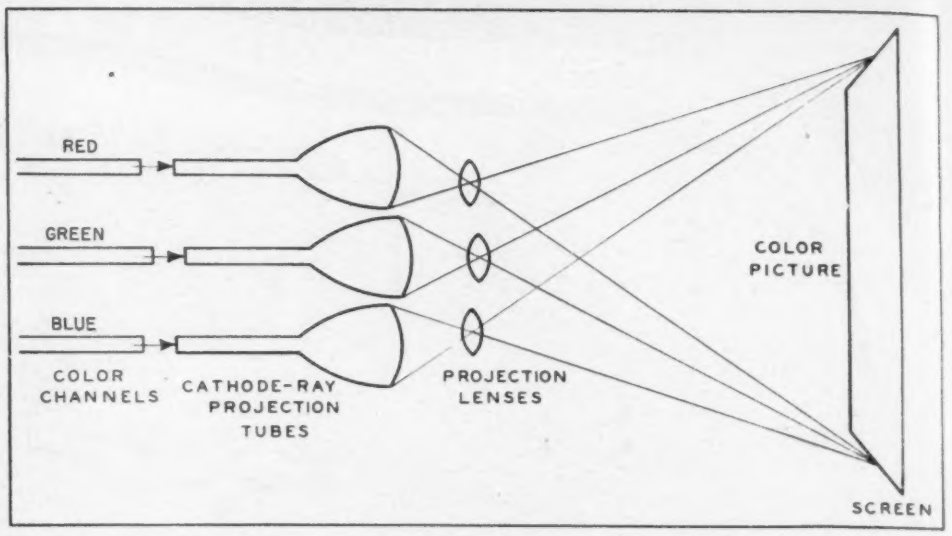


. . . AS ADAPTED FOR CONTROL OF THE REPUBLIC GAS HEATER

ers. The program televised appeared in normal black and white on the production receiver and in green on the two color models, since the green-image channel of these was being supplied with the signal.

As officials of RCA pointed out, a station owner can operate a monochrome transmitter on a low frequency and also an electronic color transmitter on an ultrahigh frequency, using the signal of the color camera to operate both transmitters.

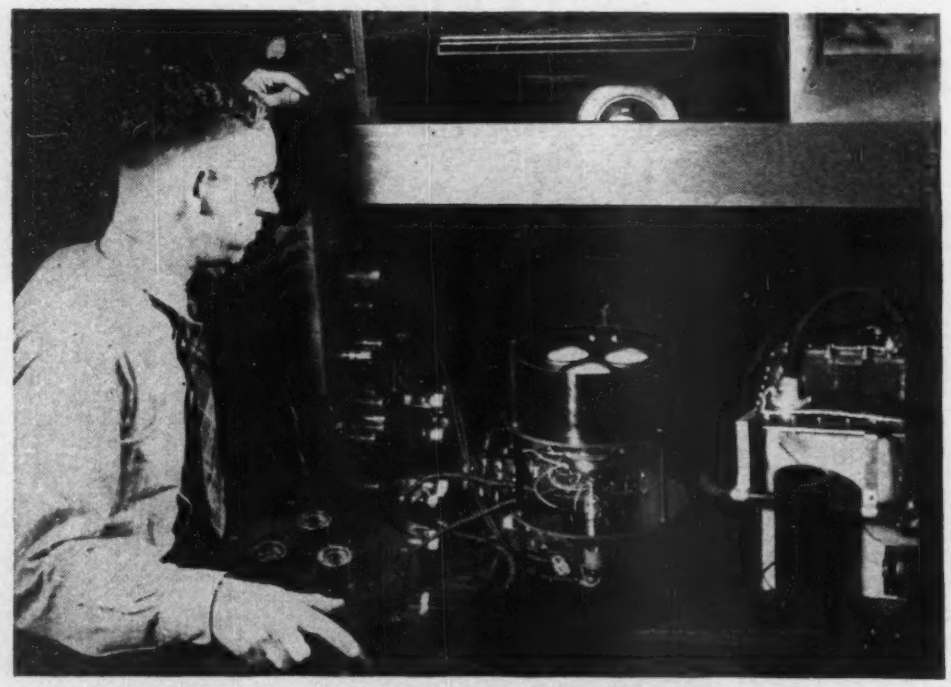
In commenting on the new electronic color system, Dr. C. B. Jolliffe, executive vice president in charge of RCA Laboratories declared, "The problem is no longer how to transmit and receive color pictures by an all-electronic method, because the basic principles have now been solved. The problem that still challenges is how to operate television broadcasting as a steady and regular service to the public on the higher frequencies, whether in black and white or in color. To open the high-frequency spectrum and to make it commercially useful will require propagation studies under broadcasting conditions, development of new circuits, new tubes and new cameras, all of which must be field-tested before commercial standards can be recommended by the industry for approval by the FCC.



In the receiver, the signal from each color channel feeds a separate cathode-ray projection-type tube. By superimposing the three images on the screen, the final color picture is obtained

"What we have done today is to demonstrate the realization of the principle of simultaneous electronic color television. The apparatus used in the demonstration is purely experimental as developed in the Laboratories. It is not commercial equipment."

Dr. Jolliffe disclosed that the remaining stages in the timetable of laboratory demonstrations of electronic color television are as follows: Motion picture films within 3 months, live-action studio scenes by the middle of 1947, outdoor action scenes by the latter part of 1947, and large-screen theatre-size pictures in 1948.



The Trinoscope consists of three cathode-ray tubes that project the colors upward to the screen in the top of the cabinet. Karl Wendt, research engineer, holds the triple lens assembly used to focus the beams

New Uses for Pentagrids

BY A. H. TAYLOR

Sound Division
Naval Research Laboratory
Washington, D. C.

IN 1937, while experimenting with the German type AH-1 hexode, a mixer similar to the 6L7 but lacking a suppressor grid, the author noticed that when grid 3 bias was changed the screen current to grids 2 and 4 varied in an opposite sense to the plate current.

These simultaneous positive and negative mutual conductances suggested possibilities as a phase in-

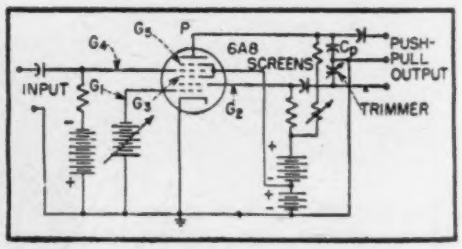
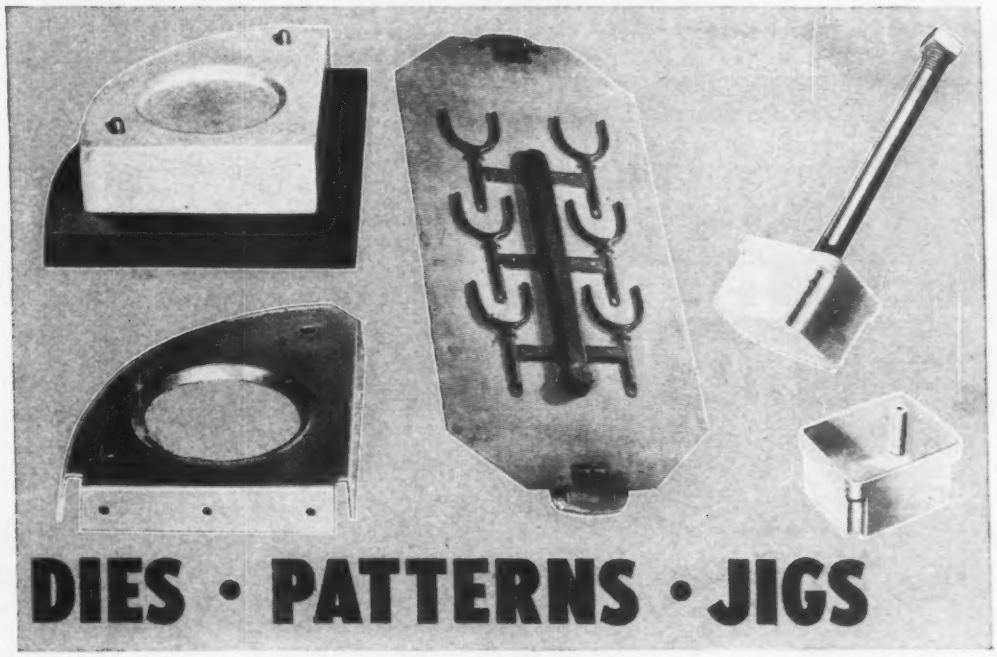


FIG. 1—Basic inverter circuit for a pentagrid tube

verter and indeed Schäfer used the similar RENS 1224 with grid 4 as a control grid and grid 3 and plate as output anodes.

For video work an inverter is desirable in which the input grid is shielded with respect to both out-



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Alert foundrymen everywhere have been quick to see the production advantages of cast Durez resin patterns such as the match plate illustrated above center. The inexpensive Durez casting resin is simply poured and cured. The perfectly reproduced pattern is then mounted on the plate. The time- and cost-saving benefits are obvious.

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The fixture, illustrated above right, for holding die-cast metal covers while a few finishing operations are performed is an excellent example of the simplicity of producing such fixtures with Durez casting resin. It was only necessary to coat the inside of one of the covers with a parting agent and pour in the resin. While the resin was in a semi-viscous state, the stud was located in place. After allowing the assembly to set for a few hours, it was placed in an oven and cured. When taken from the oven, the die-cast cover was removed and the fixture ready for use, the stud being anchored securely in the resin. Long-wearing qualities of the casting resin are excellent.

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Tests have shown that Durez casting resin may be sawed easily, that it drills like hard maple wood, that it will not hold heat or be softened by it, and that it will not ignite. Standard wood- or metal-working equipment may be used. The liquid resin follows the contours of any part exactly and holds them to predetermined tolerances. Its shrinkage factor is but .0025 inches per inch.

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puts. The pentagrid converter types such as the 6A8 seem ideally suited to this purpose when connected as shown in Fig. 1. As the experimental curves of Fig. 2 show, the current to grid 2, the oscillator anode in a conventional converter operation, varies in almost perfect symmetry to the plate current, when G_1 bias and G_3 and G_5 screen voltage are kept constant and G_4 is used as the control grid.

These curves merely change their slopes without losing symmetry seriously, when G_1 bias is varied as a means of expansion or compression or remote volume control. Figure 2 shows that the inverter should

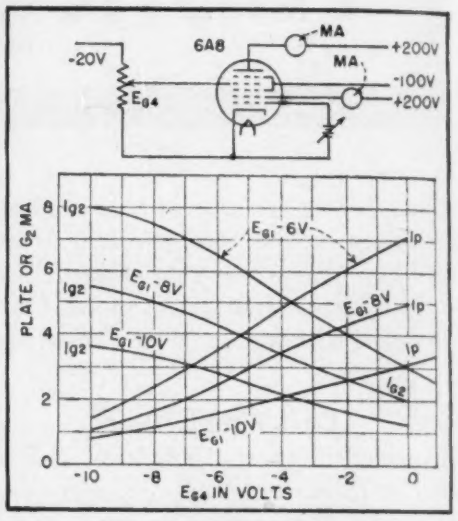


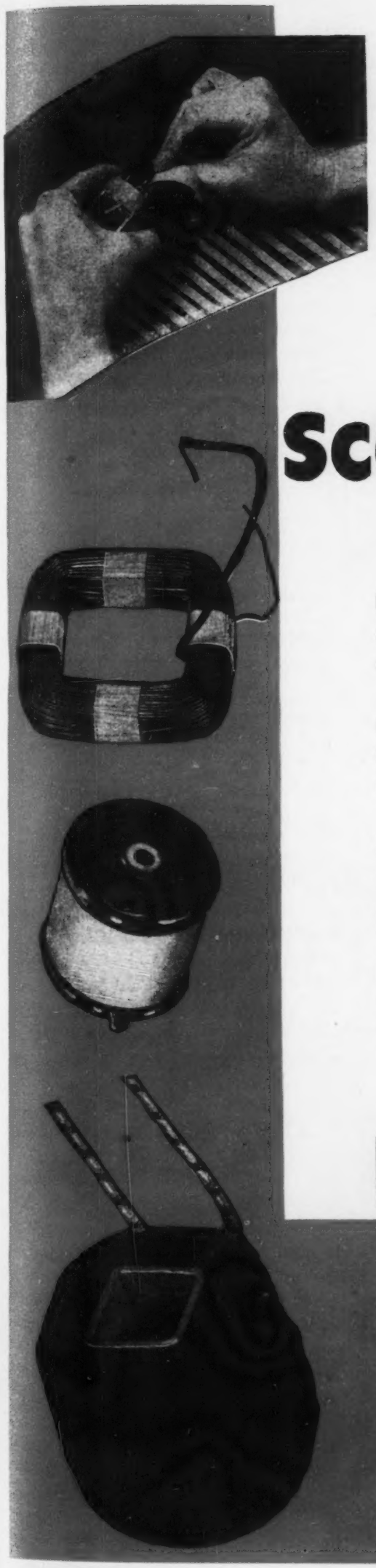
FIG. 2—Static characteristics of the 6A8 for phase inversion

be operated with G_4 biased at —4 volts, with 100 volts on the screens, and with 200 volts at G_2 and plate, G_1 bias being varied to control the gain. More conservative operation with less dissipation would follow similar characteristics at lower voltages.

Application

The outputs can be adjusted for symmetry either by juggling the voltages of G_4 and the screens, or by making one load impedance variable, both in magnitude and phase angle, and testing with a square wave.

Such a circuit is not a phase inverter in the strictest sense of the word, but an amplifier stage producing greater-than-unity gain to two oppositely phased outputs. It is used by the author in the amplifier limiter of the sweep synchronizer in a wideband cathode-ray oscillograph. Switching to either of the



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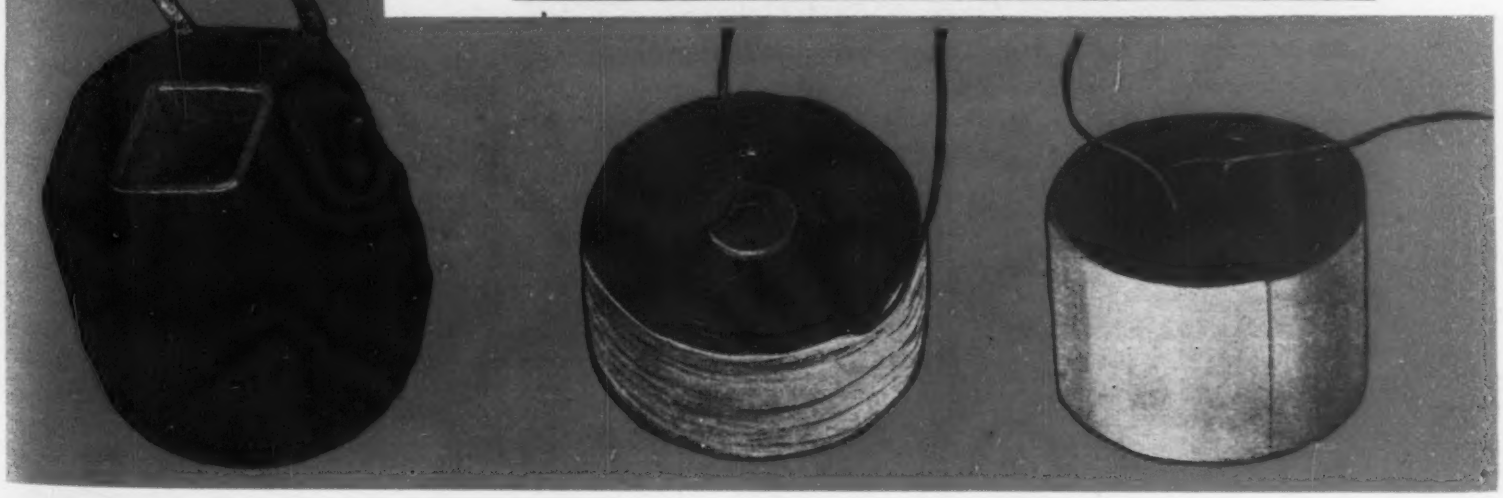

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outputs from G_2 and plate affords choice of positive or negative synchronization, a necessity in studying some wave forms.

An additional advantage of the pentagrid arrangement illustrated in Fig. 1 is the high d-c resistance that can be tolerated in the circuit of G_1. A 6A8G, used in the first stage of a multistage amplifier for small piezoelectric pressure gages, was perfectly stable with 80 megohms, and remained stable for some time, even with G_1 entirely floating. The amplification from G_1 to plate or G_2 is of course not high, but it is greater than unity except for very low load impedances.

Single-Coil Oscillator

The possibility of a very simple single-coil oscillator, having a tank circuit in G_2 and feedback to G_1, is illustrated in Fig. 3 and Fig. 4. It

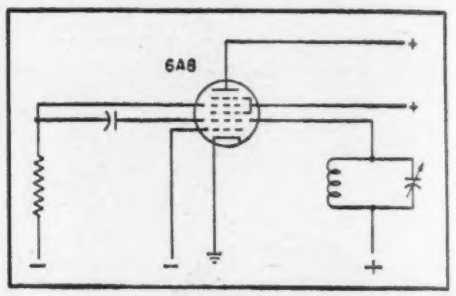

FIG. 3—Basic two-terminal oscillator circuit

would seem to have the advantage over dynatrons and transitrons that the electrode arrangements are not abnormal; the various d-c potentials are applied substantially as in the tube manual. Longer or at least more predictable tube life should be the result.

If G_1 bias and the feedback to G_1 from the plate or G_{2a}, as the case may be, are adjusted carefully and amplitude limitation is provided by an avc circuit biasing G_1, a very stable oscillator having zero grid current and extremely low harmonic content is possible.

Using the AH-1 tube, the author set up such an oscillator. Its operation was determined by test to be confined to the linear portion of the mutual characteristic. Its frequency was wholly independent of any injected signal however close in frequency and however large in amplitude, even to the point of what was called "Totmachen ohne Mitnahme"; the increasing amplitude of injected

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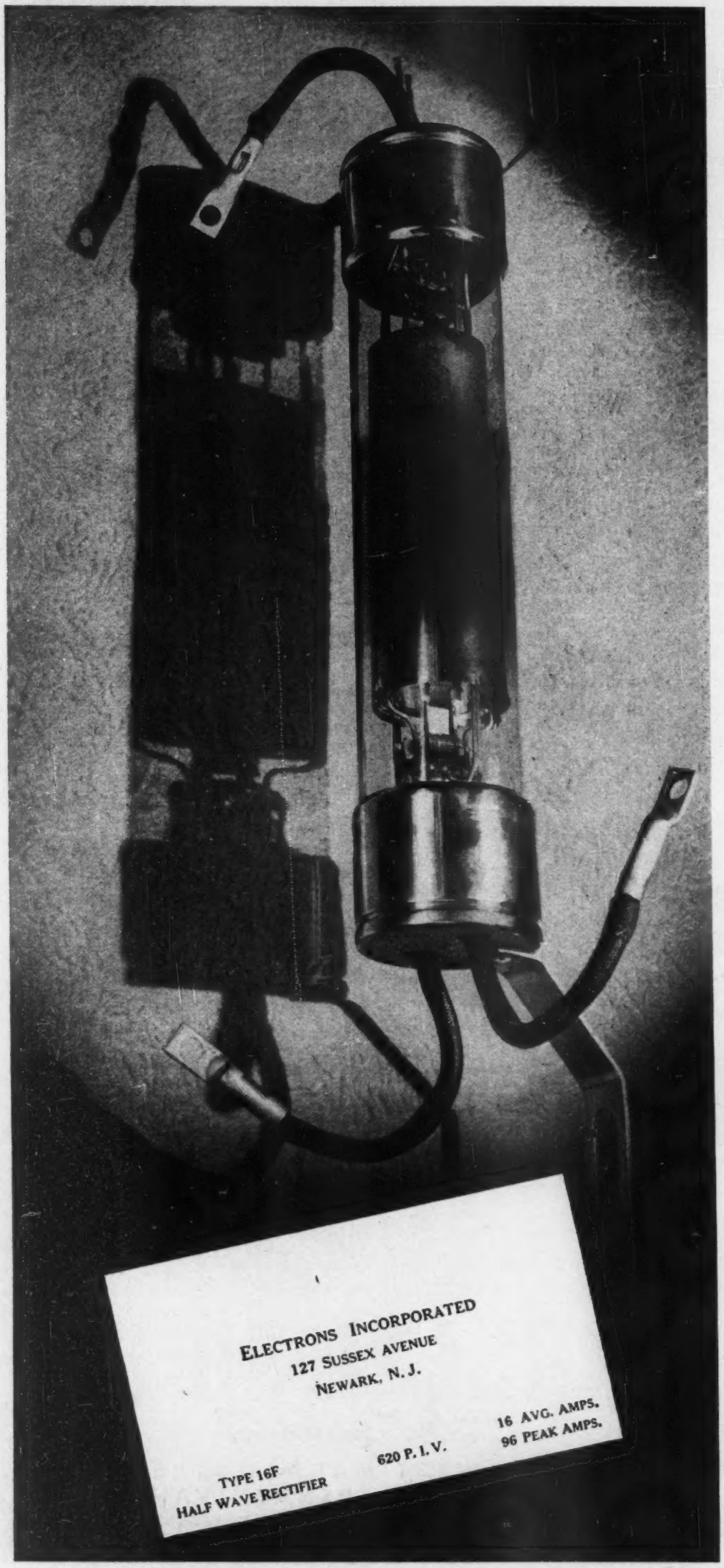

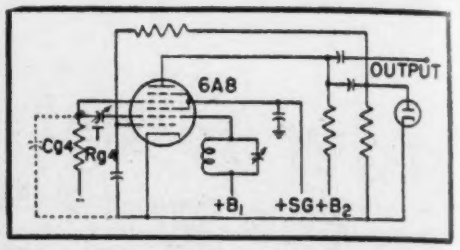

FIG. 4—High stability with compression is a feature of this circuit

signal gradually replaced the self oscillation until the latter disappeared altogether, without ever having had its frequency influenced.

This process could be observed very vividly with a cathode-ray oscilloscope; first the pure local oscillation was present, then a ripple crept slowly across the screen as the injected signal differing in frequency by a cycle or so was brought up; this ripple increased to a maximum as the two signals beat at equal amplitudes, and faded away again to leave only a sine wave after the injected signal had overwhelmed and stopped the self oscillations. This behavior is in accordance with the accepted theory that "Mitnahme" or locking depends on nonlinearity.

A pentagrid compressor crystal oscillator might be of advantage in a primary frequency standard because of freedom from grid current loading or influence by external causes. A proposed variable oscillator to replace the electron-coupled oscillators now used in variable-frequency transmitters is shown in Fig. 4. The value of R_{g4} is very high and trimmer capacitor T is adjusted to give the proper feedback through the capacitance potentiometer which it forms with C_{g4}.

Constant output amplitude over a tuning band can be obtained by using a suitably adjusted impedance potentiometer here instead of a capacitance potentiometer. The maximum permissible time constant of the filter circuit biasing G_1 is critically related to the decrement of the oscillatory system; if it is too long, blocking will result.

Direct-Coupled R-F Amplifier

By EARLE TRAVIS
Chief Engineer, Station KVEC
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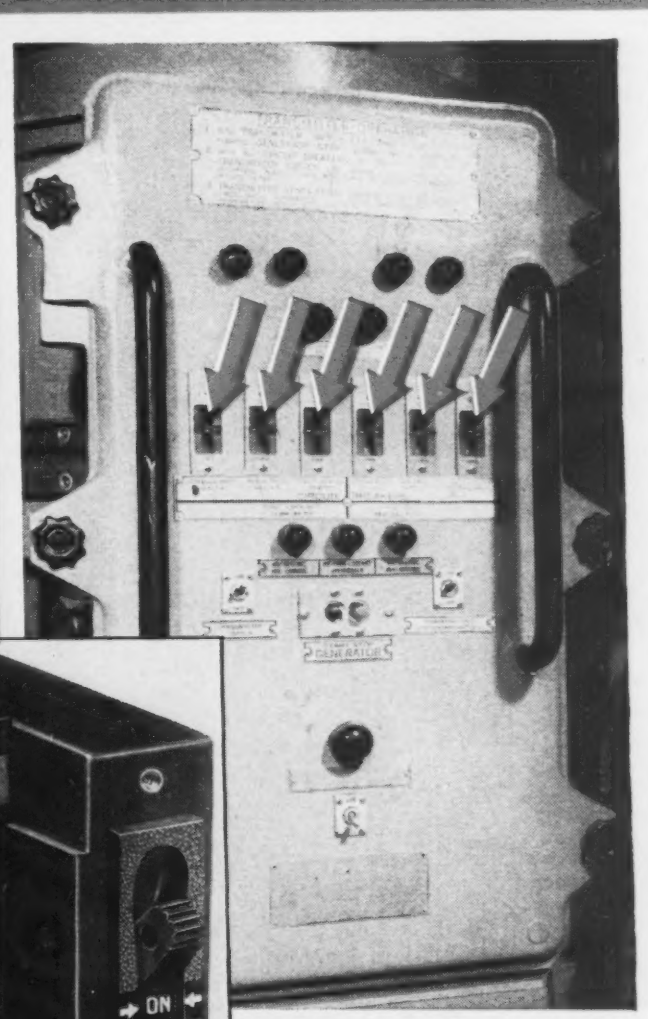

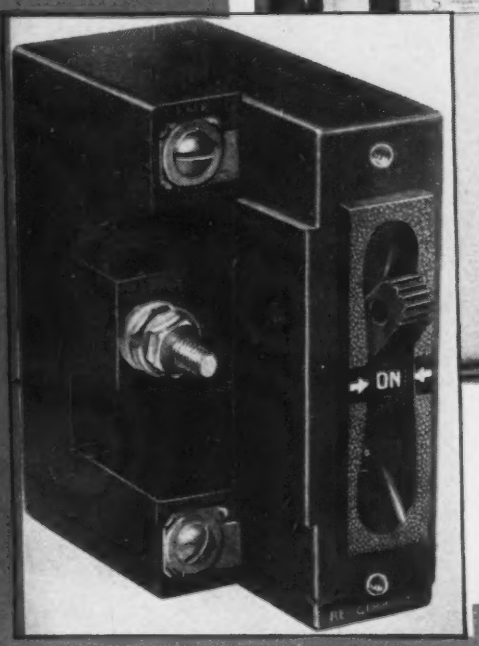

Red Arrows above show the location of six HEINEMANN Circuit Breakers in the Sperry Transmitter.

Left: — Close-up of the breaker.

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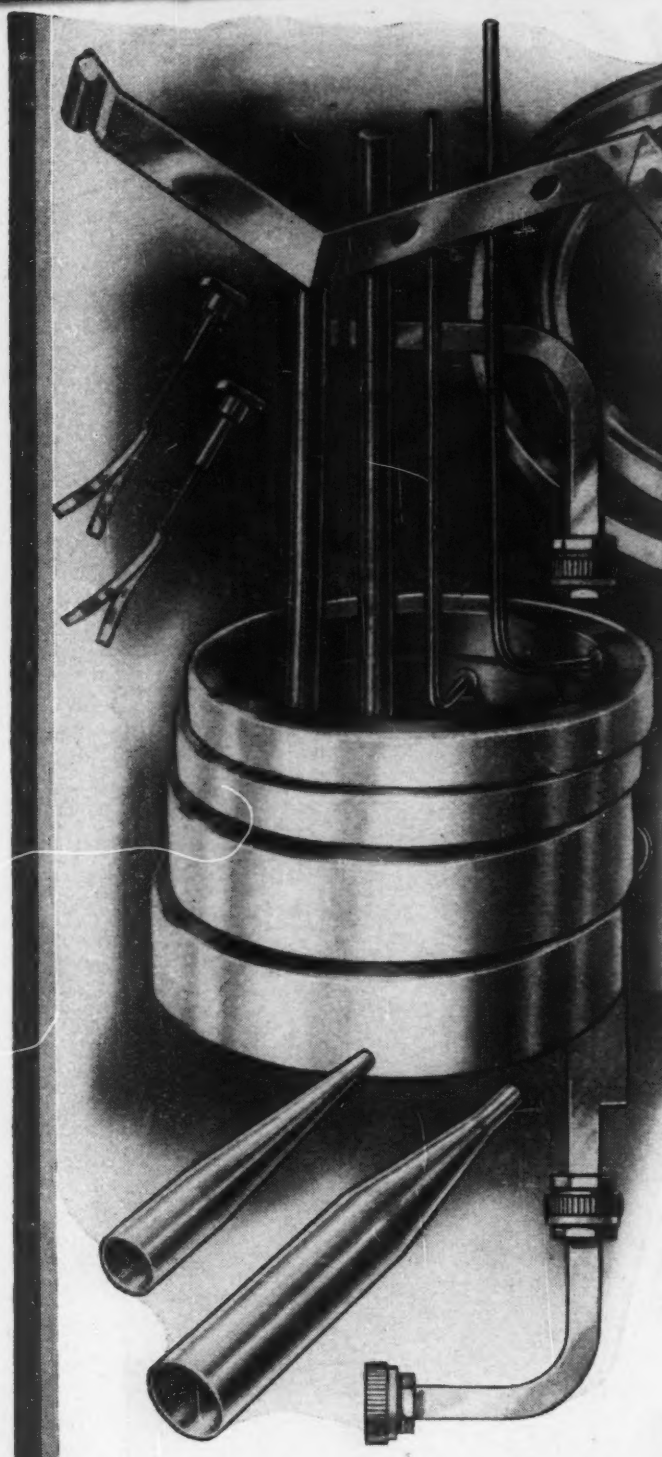

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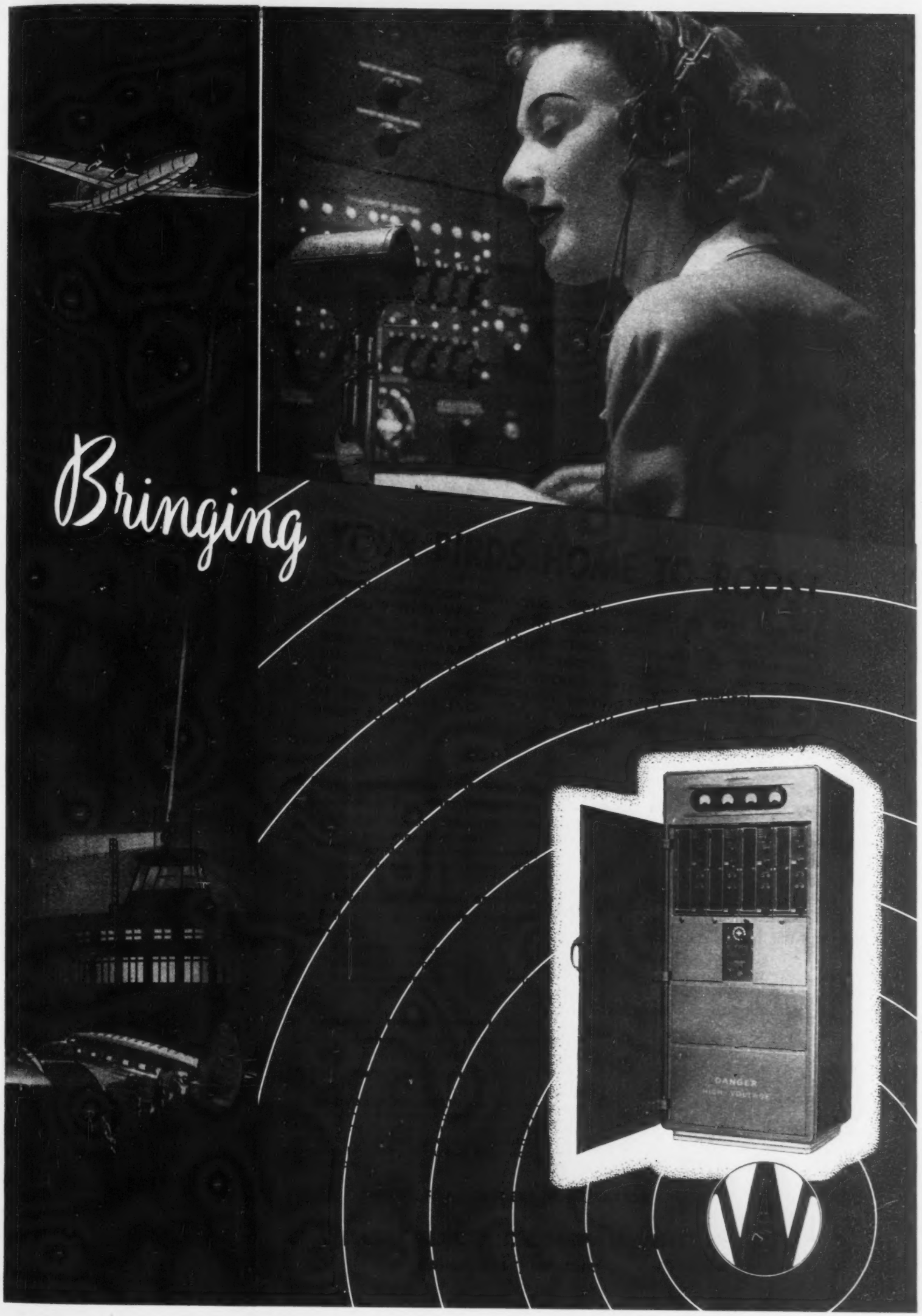
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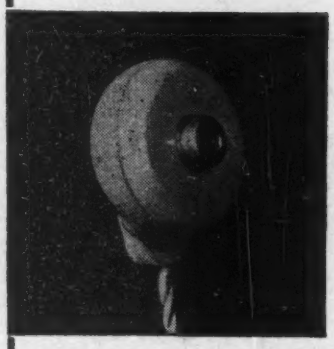

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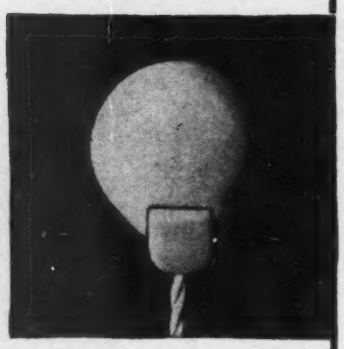

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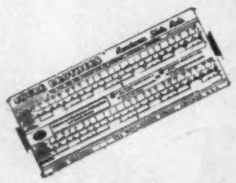

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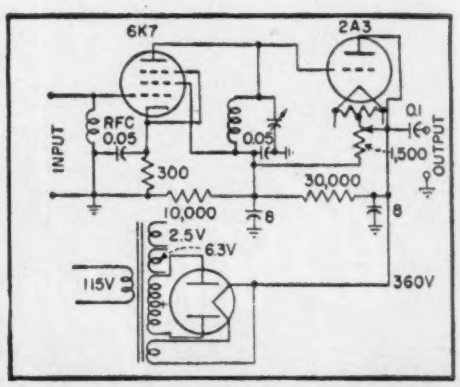
tor is essential. Otherwise the null is buried under noise and the signal of any transmitter on that frequency. As the average signal generator has a rather low output, an amplifier for it is a decided advantage.

An amplifier for this purpose should be completely shielded and nonoscillating. It is an advantage to have a low-impedance output to match the low-impedance cables furnished with the bridge. The circuit shown in the diagram meets all



Circuit of high-gain direct-coupled amplifier for use with a signal generator

these specifications. The reason for making it direct coupled is that this does away with all untuned circuits between the 6K7 and the 2A3, allowing the 6K7 to produce a relatively high gain.

If it is desirable to have a constant output impedance, the output voltage of the amplifier may be varied by detuning the tuned circuit. No values are shown in the diagram for the tuned circuit as its values depend on the frequencies over which the amplifier will be used.

Multiple Thyratron Circuits

By IRVING SAGER
Thermionics Branch
Evans Signal Laboratory
Belmar, N. J.

ENGINEERS THAT work with thyratrons are occasionally limited by the power-handling capacity of the tubes. Doubling or quadrupling the power capabilities can be achieved by operating thyratrons in series, parallel, or series-parallel as has been done with thyratron line-type modulators for pulsed radar sets.

The conventional line-type modu-

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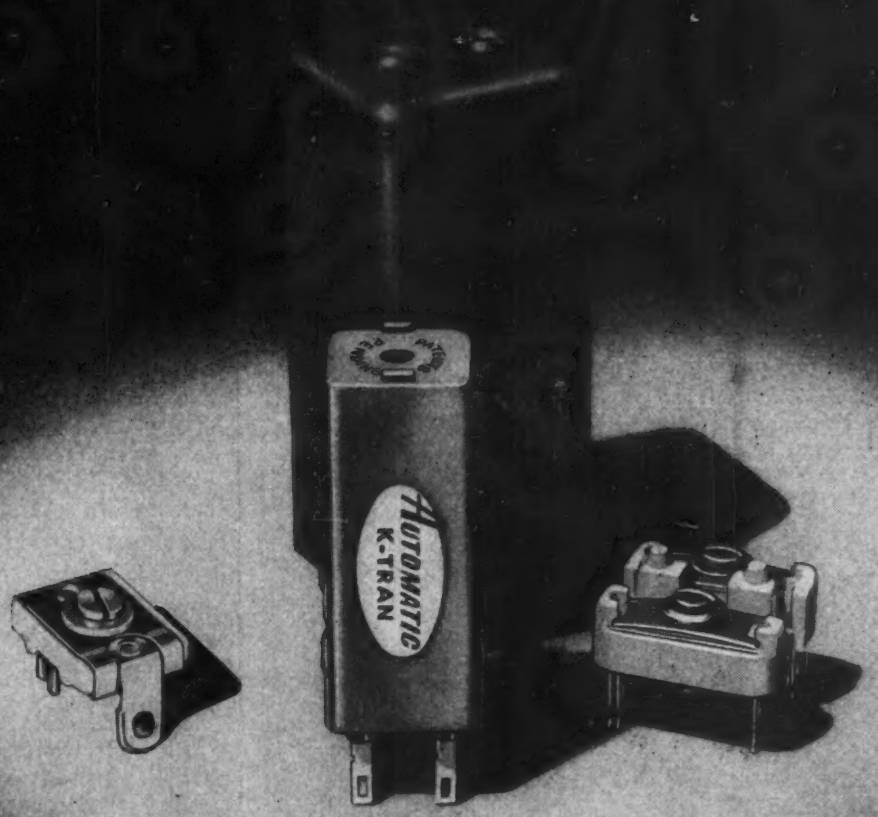

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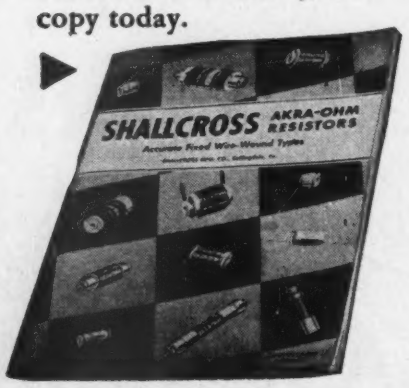

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lator schematic is shown in Fig. 1. The voltage waveform on the thy-

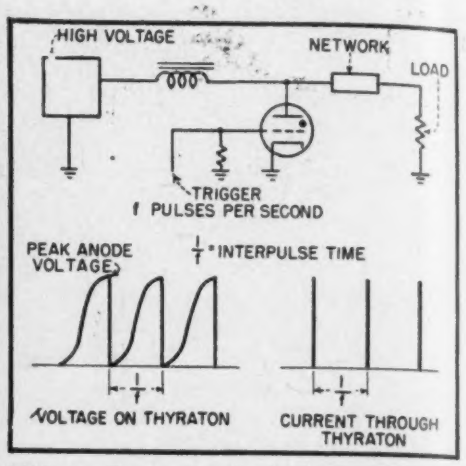

FIG. 1—Conventional single thyratron circuit as used in a line-type modulator

ratron in this circuit when a resonant charging system is employed is also shown. During the charging period, the thyratron anode voltage increases sinusoidally to a value which is approximately twice the high-voltage supply. When the thyratron is triggered, the anode voltage drops rapidly to near ground potential and permits discharge of the network through the load. In radar sets the usual load consists of a magnetron or triode oscillator, coupled to the network by means of a pulse transformer. During the network discharge time, the thyratron passes a pulse of current, the duration and waveform of which is controlled chiefly by the constants of the network.

Usually, the load impedance is made equal to the characteristic impedance of the network; therefore, the voltage appearing across the load is one-half the peak anode voltage of the thyratron. The maximum peak power available from a thyratron in this type of circuit is half the peak anode voltage rating multiplied by the peak anode current rating. To permit operation of this circuit at higher power levels than could be achieved with available tubes, various methods of employing thyratrons in multiple were devised.

In multiple operation of thyratrons, the load should be divided equally between the tubes. The time delay of firing a thyratron varies from tube to tube and during its life. The time interval between the initiation of grid voltage and the beginning of anode

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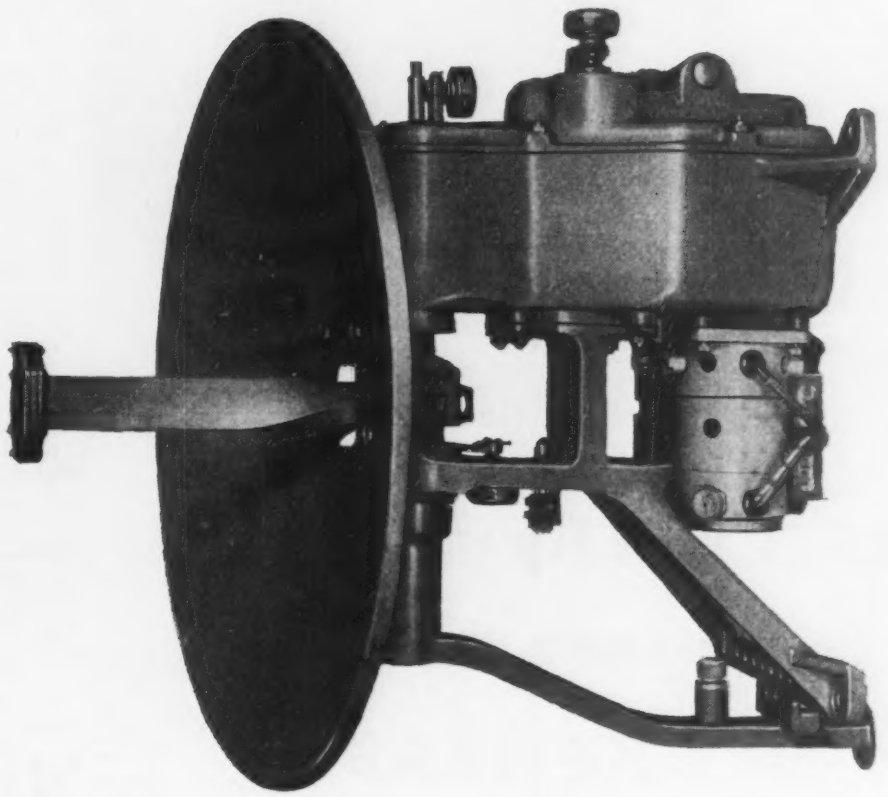

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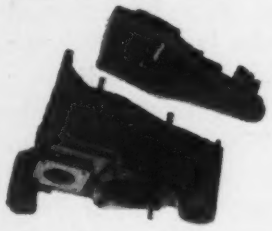

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The AN/APS-4 Antenna weighs less than 13 pounds! Quantity production was accomplished through good basic design, incorporating magnesium castings, aluminum reflectors, and snap retaining rings.

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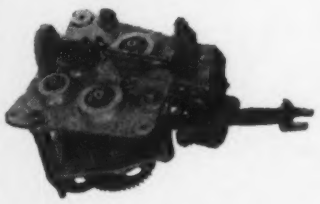

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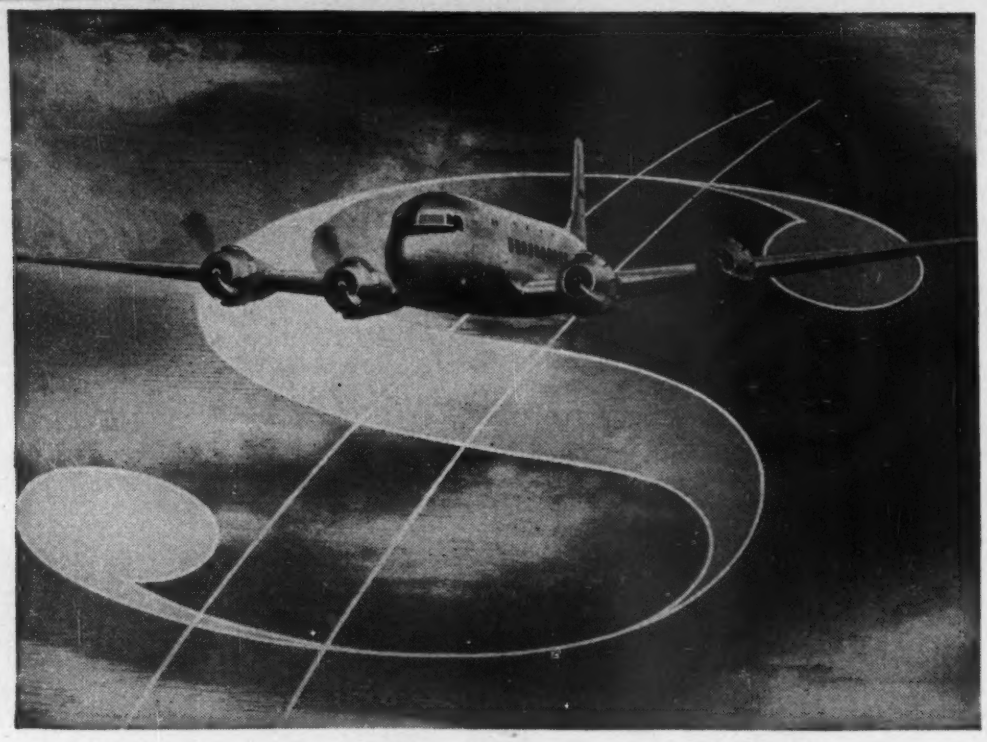

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current is called time delay. It is necessary to insure that each tube starts conducting anode pulse current at the same instant. If one tube starts conducting appreciably before the second tube, the output waveform will be distorted.

Series Circuit

The operation of thyratrons in series automatically insures that both tubes will conduct anode current during the same period of time and hence the output pulse shape will not suffer. It also insures that the tubes will conduct equal currents. By means of a resistance voltage divider, the circuit voltages may be adjusted so that each tube is subjected to half of the peak network voltage.

The series arrangement is shown in Fig. 2. When the trigger pulse is applied to tube 1, the tube fires and the voltage at point *X* drops to practically zero. As a result of this, the potential across tube 2 will start to increase very rapidly and will reach a value equal in magnitude to the voltage that appeared across tube 1 when the trigger was applied. The distribution of voltage

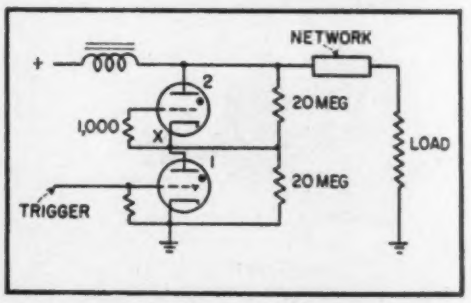
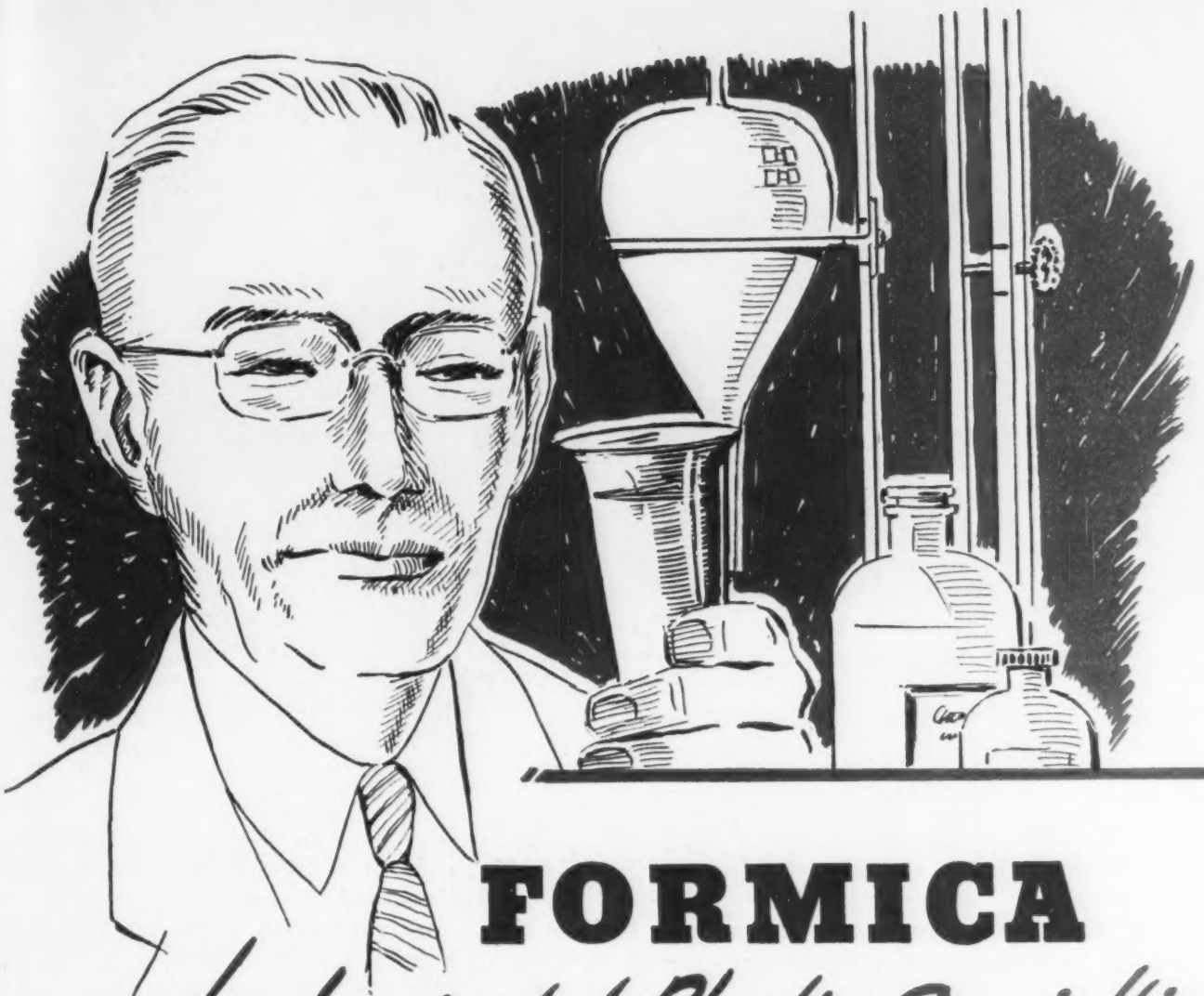


FIG. 2—In the series circuit, use is made of the tube interelectrode capacitances to supply the trigger to tube 2

within the tube to this steep wave front will be determined by the interelectrode capacitances. In the case of the 5C22 hydrogen thyratron, the grid-anode capacitance is approximately equal to the grid-cathode capacitance and about one-half of the steep pulse voltage will be applied to the grid of tube 2, making it unnecessary to supply any other trigger. Although the voltage applied to the tubes by the charging operation can be split by means of the voltage divider, the actual voltage on tube 2 at the instant of breakdown is higher than the desired value.

Tests made on the series circuit



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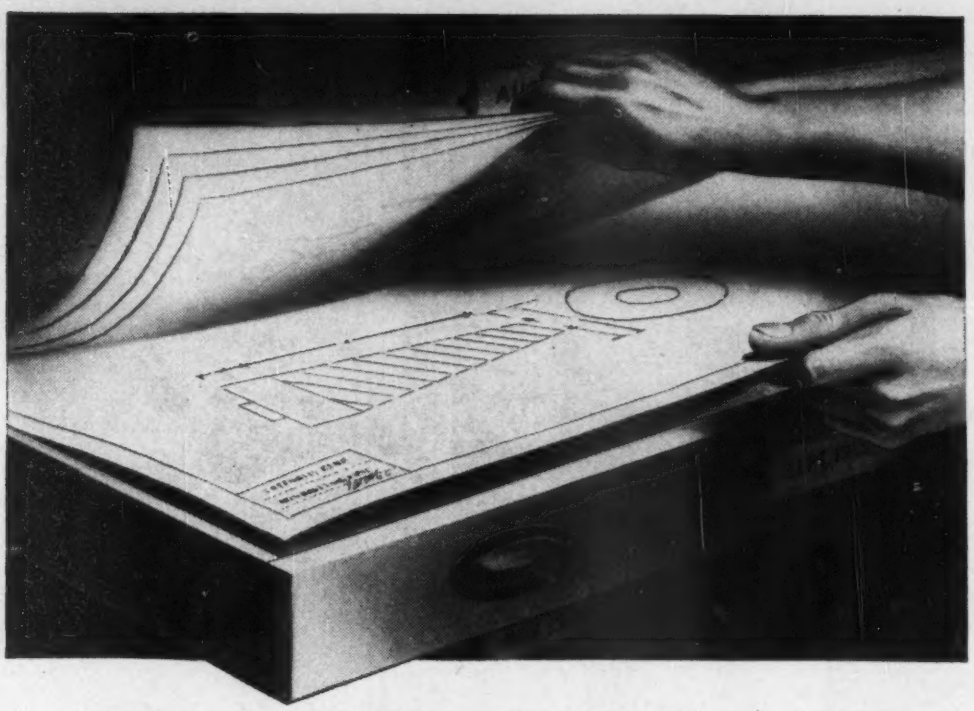

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used a voltage divider consisting of two 20-megohm resistors. A low-capacitance filament transformer was used to heat the filament of tube 2. The capacitance of this transformer will disturb the charging-voltage distribution at high repetition rates and hence should be kept small.

Shunt Circuits

Parallel operation of thyratrons may be achieved simply by using separate pulse networks for each tube, provided that the variation in firing time normally encountered does not adversely affect the output pulse shape. On very wide pulses, the effect of one tube starting conduction a fraction of a microsecond before the other is not a serious disadvantage. However, on narrow pulses (about 5 microseconds), the variation in firing time of a few tenths of a microsecond must be considered. Under these conditions it is necessary to provide some method of preventing power pulse current from flowing until both tubes have been ionized.

Figure 3 shows a parallel thyratron circuit with a single pulse network. The grid of tube 1 is fired by a conventional thyratron trigger. Point *X* on the circuit drops to practically ground potential. For a small period of time (0.1 to 0.25 μsec for 5C22 tubes), tube 1 is ionized and is capable of passing the power pulse. However, the secondary of transformer *T* sees an open circuit (because tube 2 has not fired) and hence prevents the power pulse from flowing through tube 1. Transformer *T* is a 1:1 phase-reversing pulse transformer.

A negative pulse appears at terminals *XZ* of the transformer because of the firing of tube 1. This negative pulse is reversed by

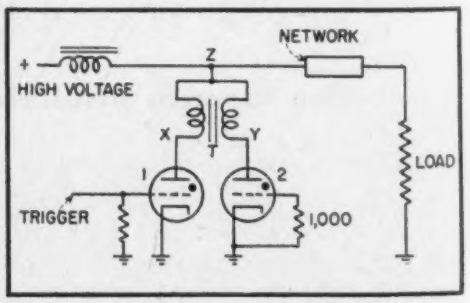

FIG. 3—A delay time of only 0.25 microsecond is possible with this parallel arrangement

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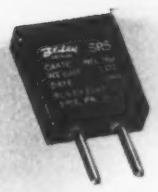
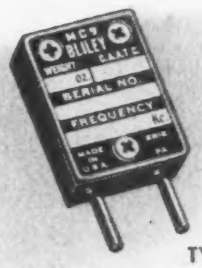
Write for Bulletin 27

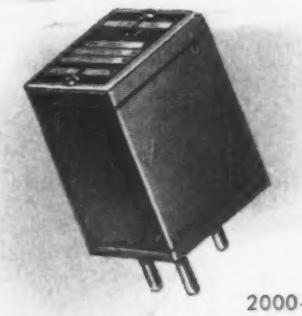
Bliley CRYSTALS



2000—11000KC
TYPE SR5—CAATC No. 363



3000—11000KC
TYPE MC9—CAATC NO. 362



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TYPE AR5W—CAATC NO. 361

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Send for Bulletin 10

BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY, U. S. A.

the transformer, and the anode potential of tube 2 starts increasing.

The increase in anode potential of tube 2 causes its grid to become positive because of the grid-anode capacitance and firing of tube 2 is accomplished in a manner similar to the firing of tube 2 in the series arrangement.

When both tubes are conductive, the transformer equalizes the currents in the tubes by virtue of the unity turns ratio. The impedance it offers to the main pulse energy is presented only by its leakage inductance. The actual added circuit inductance is equal to one-fourth the sum of the primary and secondary leakage.

Measurements on Sylvania 5C22 tubes showed that in the parallel circuit the maximum delay time (time between the instants of firing of the two tubes) for tube 2 was 0.25 microsecond. The transformer used for the tests consisted of two coils of 15 turns wound on a 0.002-inch Hipersil core of three square inches area. This transformer satisfactorily passed main anode pulses of 1.5 μsec and 5 μsec at 16 ohms impedance.

Because of the extremely rapid rate of rise of voltage applied to the grid of tube 2 in both the series and parallel circuits the increase in jitter introduced by the addition of the second tube is reduced to a minimum. Measured values of jitter in two-tube circuits were always less than 0.04 μsec.

Combination Circuit

Combining the series and parallel circuits permits operation at extremely high power levels. The circuit used for accomplishing this is shown in Fig. 4. It is only neces-

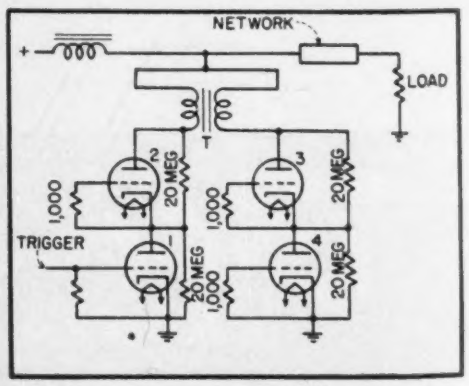
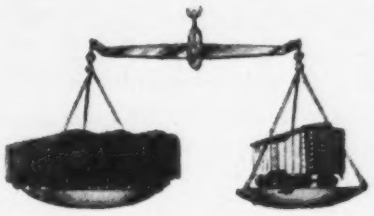


FIG. 4—Using the methods discussed in the text, this series-parallel circuit is evolved

CELANESE* PLASTICS

join the model railroad brotherhood



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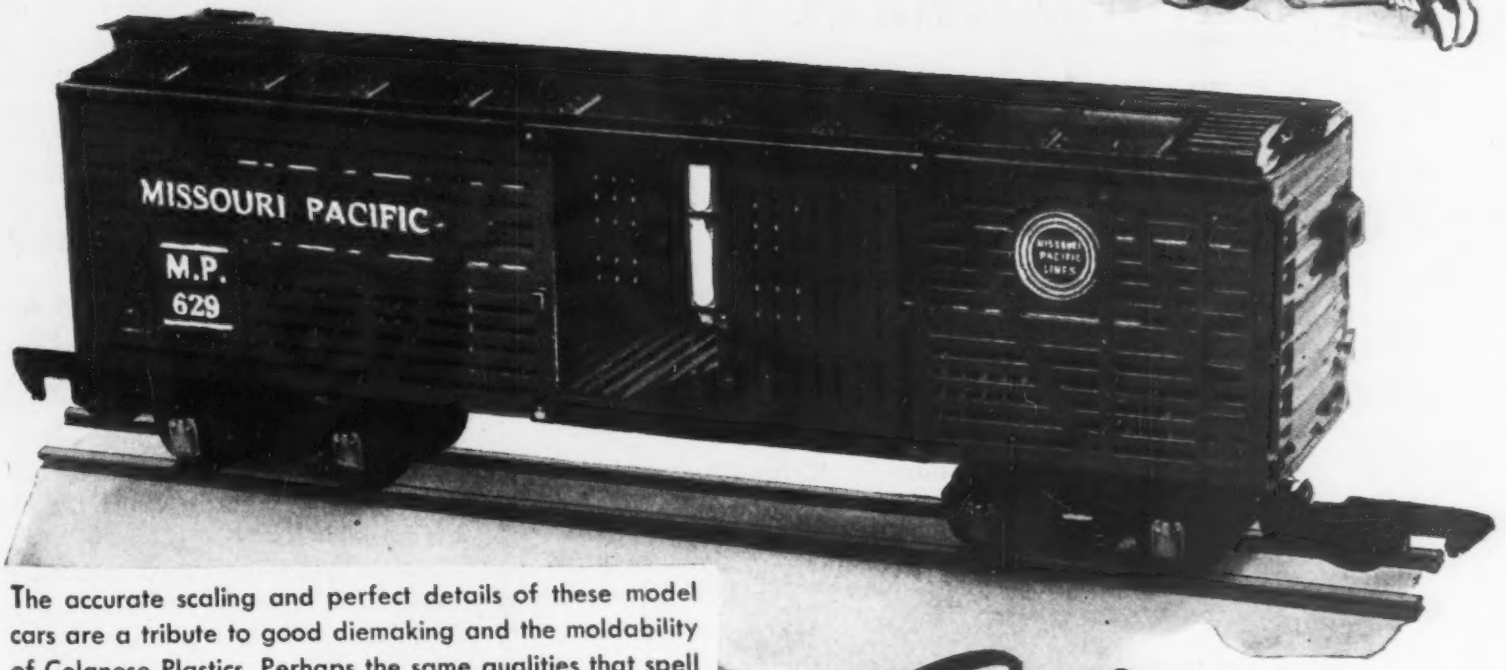

The accurate scaling and perfect details of these model cars are a tribute to good diemaking and the moldability of Celanese Plastics. Perhaps the same qualities that spell success for Celanese plastics in model railroading can be used to advantage in your products. The Celanese technical service staff is prepared to show what the high-speed moldability, clear-through color and all-around production economies of Celanese plastics can do in improving products and reducing costs. Celanese Plastics Corporation, a division of Celanese Corporation of America, 180 Madison Avenue, New York 16, N. Y.

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sary to trigger one of the four tubes. When tube 1 is triggered, tube 2 becomes ionized in a manner similar to that of series operation. Then after tubes 1 and 2 are ionized, transformer *T* operates as before and triggers tubes 3 and 4. Which of these becomes ionized first will probably depend on the individual tube characteristics. A modulator using this circuit and four 5C22 tubes has been constructed and will handle 30,000 volts, 2 microseconds, with 200 pulses per second. It has been operated satisfactorily at about 10 megawatts.

High-Fidelity Phonograph

FREQUENCY RESPONSE within plus or minus one db over the range from 50 to 14,000 cycles is a feature of a new phonograph, the London Reproducer, now on the American market.

The circuit of the amplifier contains four stages of pushpull triodes. A low-impedance balanced-armature pickup feeds via bass-compensating R-C circuits to the grids of two 6J5 triodes. After passing through a second set of 6J5's, the signal is fed through a compensated twin volume control to another pair of 6J5's which are capacitively coupled to the grids of two PX25 output tubes. (The British PX25 is somewhat similar to the 2A3 but has a higher output rating.)

Each grid load is provided by half of a center-tapped choke having paralleled resistors, so that at all audio frequencies covered the inductive portion of the load is approximately four times that of the resistors to maintain linearity at low frequencies.

In the first three stages, separate unbypassed cathode resistors are used for each tube to correct any existing unbalance and nonlinear distortion. Volume control between stages 2 and 3 is achieved by twin resistance-capacitance circuits shunted across the output of stage 2, anode to anode, the capacitive portions of the network providing bass compensation at low volume levels.

Eight tubes are used, six 6J5

For the "WHERE and HOW to use WHAT PLASTIC"

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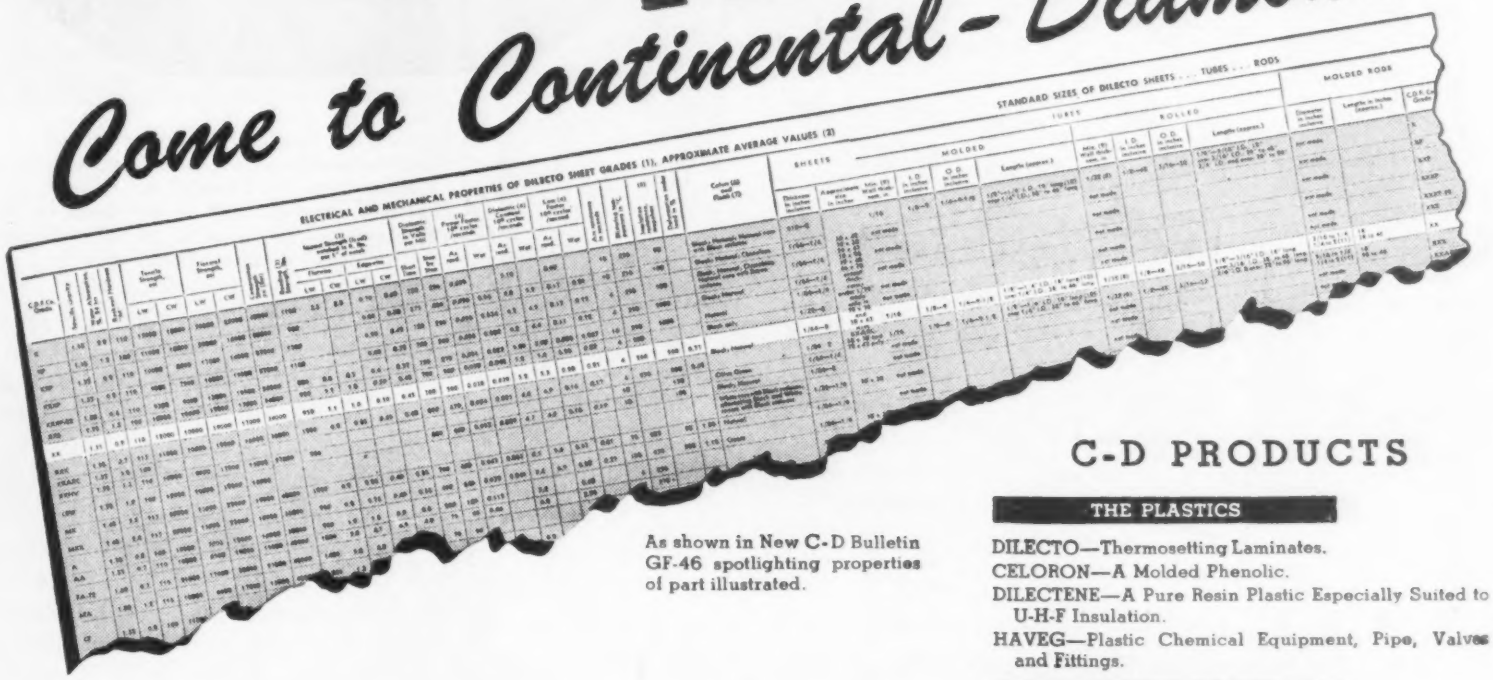
ELECTRICAL AND MECHANICAL PROPERTIES OF DILECTO SHEET GRADES (1), APPROXIMATE AVERAGE VALUES (2)
STANDARD SIZES OF DILECTO SHEETS . . . TUBES . . . RODS
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TUBES
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SEC-46

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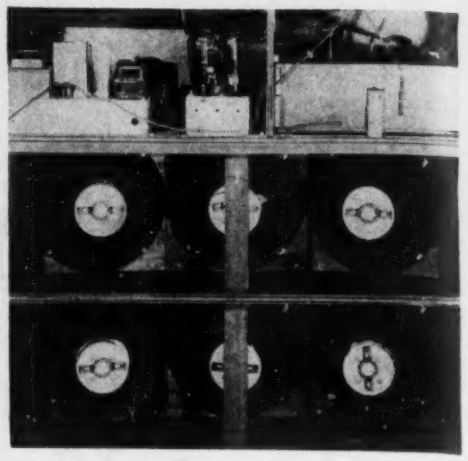
triodes and two PX25 triodes, all in matched pairs. The rectifier is a 5U4G. Precaution against damage to the output tubes has been



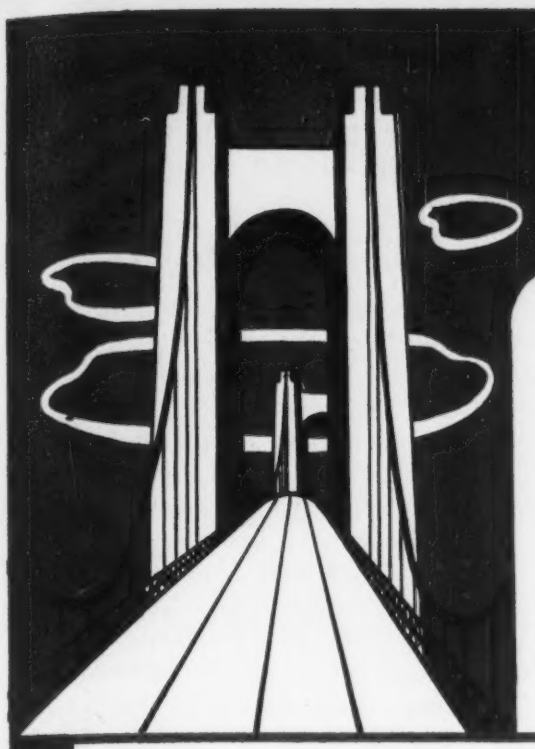
Electronic portion, record changer, and loudspeakers of the London Reproducer as viewed from the back of the cabinet. The speaker arrangement is designed to provide 180-degree sound dispersal and avoid high-frequency beam effects

taken by providing individual cathode bias resistors and grid and anode series resistors that act as stoppers to stop parasitic oscillation.

Power consumption in the London reproducer runs to 130 watts at 110 volts and the amplifier output is six watts at 1,000 cycles. It is unnecessary to have a higher wattage because of the efficiency of the speakers. This limitation on a circuit which is normally capable of producing about 12 watts at ordinary distortion levels results in an exceptionally low distortion figure, below one percent. The hum level runs around —50 db.

The record changer is a Garrard R.C. 60 which can play eight 10- or 12-inch records interchangeably. The needle armature unit is about the size of a half-walnut shell and places a weight of only 27 grams on the disc. The case of the pickup is of moulded plastic, the two halves being hinged at the rear and secured by a single screw. The sapphire point is free from self-resonance over the frequency range, and has a radius which enables it to track the highest audible frequencies accurately.

Two models are available, one having three 12-inch p-m loudspeakers, the other having six. Of interest to designers of high-fidelity equipment who are price conscious, the London Reproducer



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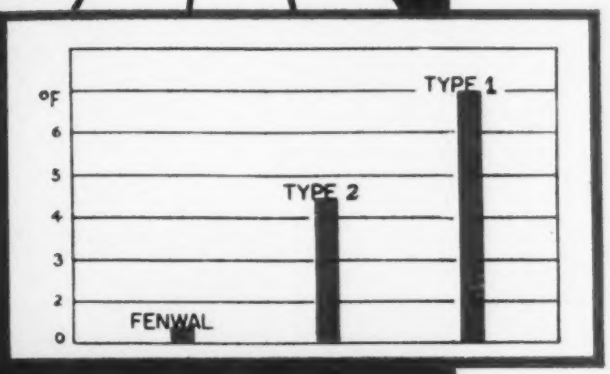

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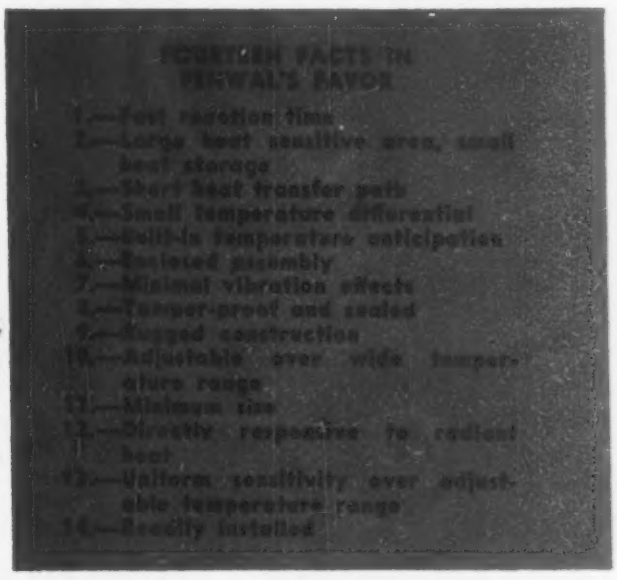

*#9 of the "Fourteen Facts in Fenwal's Favor".

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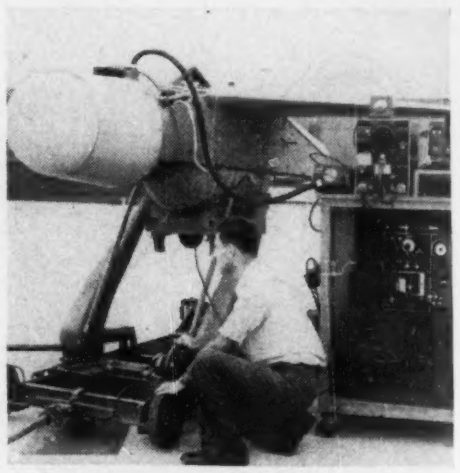
ranges from $1495 to $2500. No tuner is provided, but space is available in the cabinet.

Radar-Guided Bomb

THE FIRST fully automatic guided missile to be used successfully in combat by any nation was the Bat, a flying bomb launched from a plane and guided to its target by radar. The name suggests the principle on which the weapon operates since live bats give out a short pulse of sound and guide themselves by the echo.

The Bat is a low-angle-of-flight, self-controlled airborne homing missile. It carries a bomb mounted in a glider type airframe (air stabilizer) which is equipped with a radar transmitter and receiver to provide directional correction, a gyroscopic stabilizing unit, and a servo system to move the control surfaces of the air stabilizer. The complete unit is carried by aircraft, suspended under a wing or below the fuselage.

The transmitting antenna, as well



Special electronic gear is used to check the Bat before it is loaded under the carrying plane

as the return pickup for the radar, are in the nose, concealed by a half-spherical wooden shell. The impulses are transmitted from a cross-shaped antenna, the arms of the cross being about six inches across. Directly behind this is a 12-inch metal reflector, mounted off center. When the Bat is in flight, the reflector whirls rapidly with the same sort of gyration performed by a phonograph record off-center. Because of this eccentric movement, it is possible for the gyro and radar

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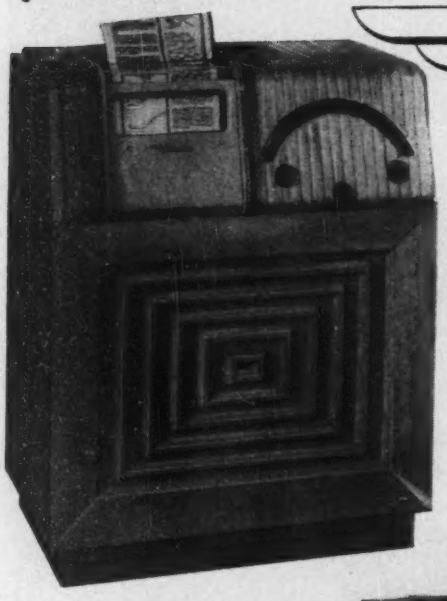
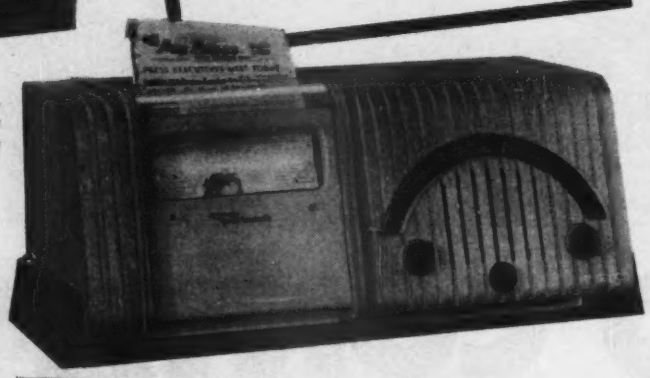


New Finch AM-FM Radio for receiving both sound and facsimile. Console model



New Finch AM-FM Radio for receiving both sound and facsimile. Table model

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pickup to determine whether the impulses bouncing off the target are coming from the right or the left.

In directing the course of the Bat, the radar unit and gyro work together, the gyro transmitting to the servo unit proper instructions to keep the bomb on even keel, and the radar at the same time transmitting directions to the servo for any necessary changes in course.

The servo manipulates the control surfaces of the wings of the bomb. The weapon is not propelled; the power for the glide is obtained from the speed at release and the pull of gravity.

Operation

The target is located by the standard search radar of the plane. The plane is then headed toward the target and the radar transmitter and receiver in the weapon are directed toward the selected target. The target data from the radar in the missile are displayed on a separate electronic indicator, mounted in the parent plane, which is controlled and interpreted by the operator. After the radar equipment is manually adjusted it is switched to automatic tracking. The plane is maneuvered to aim the Bat.

After release, the missile is completely self-controlled and automatically homes on the selected target. The plane is free to pursue any desired course of further attack or evasion.

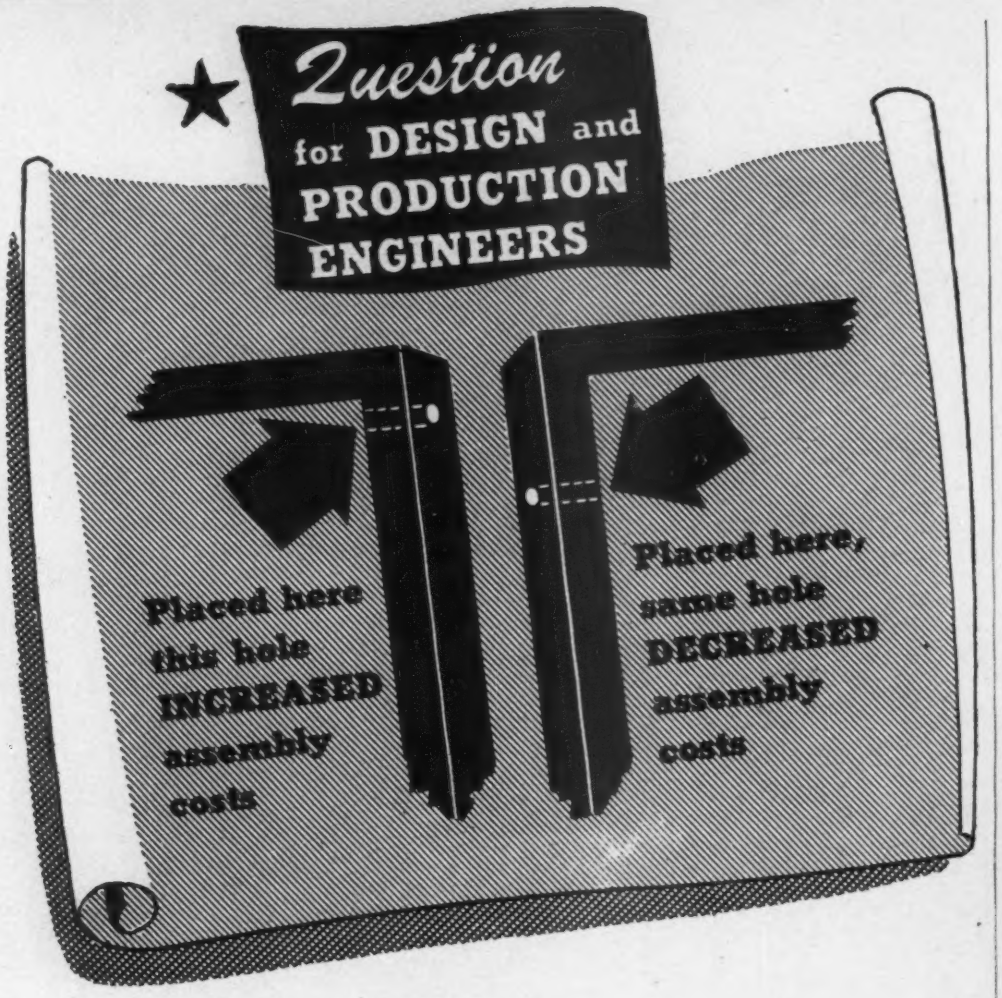
Directional correction of the weapon is obtained through the illumination of the target by the radar transmitter in the Bat. Thus echos from the target are continuously detected by the radar receiver and the output to the flight control units indicates the direction of the target with respect to the axis of the missile.

The Bat is approximately 12 feet long, and has a 10-foot wing span. Its speed is comparable to that of high-speed aircraft and its range great enough to allow the mother plane to operate well out of the enemy's longest-range anti-aircraft fire. This missile was developed by the Bureau of Ordnance of the U. S. Navy to accomplish long-range, high-accuracy bombing from aircraft regardless of visibility conditions of the target. Though de-

NC-2-40D

Beauty goes deep in the NC-2-40D. Deep inside the chassis parts of watchlike precision are assembled with painstaking care. Carefully designed mechanisms enable the controls to respond to your slightest touch. Thorough shielding helps circuits to develop the fine performance, stable operation and uniform response that you expect of a National receiver. We invite you to study the photographs above. They are pictures of quality.

NATIONAL COMPANY, INC., MALDEN, MASS.



★ What have assembly costs and to do with size or location of holes for fastenings?

MILFORD FASTENING EQUIPMENT

The connection is as close as the fingers of your hand.

A fraction of an inch one way in the size or location of a hole — and *standard* Milford fastening equipment can be used: *thousands of dollars added to profit.* A fraction of an inch the other way — and *special* Milford fastening equipment must be used: *thousands of dollars added to cost.*

To see how an assembly that apparently requires special Milford fastening equipment could be done faster and at lower cost with standard equipment comes from knowing all the mechanical possibilities of fastenings with rivets and rivet-setting machines.

Milford engineers will gladly share their vast knowledge of the intricate field of fastenings so that wherever possible, standard equipment may be used. (It's simply good business to keep customers' costs down.)

Even before a design reaches the drawing board, explore fastening methods with a Milford engineer. Consultation is in strictest confidence and without obligation.

THE MILFORD RIVET & MACHINE CO.

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THE PENN RIVET & MACHINE CO., PHILADELPHIA 33, PENNA.

Designers and Manufacturers of: SPECIAL COLD-HEADED PARTS; SPLIT, SEMI-TUBULAR AND DEEP-DRILLED RIVETS; RIVET-SETTING MACHINES; SPECIAL MACHINE SCREWS AND SCREW MACHINE PARTS.

signed primarily for use against sea targets, under certain conditions it may be effectively used against land targets.

The Bat may be carried by carrier fighters or other shipborne aircraft as well as Navy Privateers. The flight characteristics of the aircraft are only slightly affected by the Bat, and flight operations are not at all affected.

ULTRASONIC DEFOGGER

Although not itself intended to disperse fog, the machine shown above is used experimentally by Ultrasonic Corporation to determine the requirements of equipment which it is hoped will disperse fog ultrasonically. In the laboratory, fog particles bombarded by sound waves collide, form masses heavy enough to fall as rain

GUIDED MISSILE PLOWSHARE

Radio control equipment used in the Queen Bee, target plane for AA practice, has been adapted to control an English farm tractor

HOW TO PRESERVE A SCHEMATIC DIAGRAM

Here's a schematic diagram that will last as long as the equipment on which it goes—in years to come, maintenance men will be able to get at a glance the information they need.

It's made of tough and durable G-E Textolite laminated plastics and has good chemical, weathering, and impact resistance—excellent electrical insulating properties too. The precise drawing in red and black is quick to read, and strong construction insures this readability for many years.

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INDUSTRIAL CONTROL

Edited by VIN ZELUFF

Fault Locator for Power Lines 198

Supersonic Flaw Detector 198

Resin Adhesives for R-F Heating 202

Materials Tester 206

Fault Locator for Power Lines

THE CIRCUIT OF AN instrument for location of accidental grounds on overhead electric power distribution lines is shown in the diagram. These grounds are frequently not visible by patrolling the lines, and may occur on any one of numerous lateral taps of the main primary circuit. Lightning arresters, particularly the older types still in service in large numbers, are frequent offenders.

Before using the instrument, the fault circuit is energized from the normal power source through a capacitor. The resulting current flow can then be followed with the fault locator directly to the fault location. The sensitivity of the electronic fault locator permits following rural primary lines by car at a distance of 100 yards or more.

An electrostatically shielded loop antenna consisting of 1,500 turns of enameled wire wound in a steel housing is used to pick up the fault current. A shielded cable conducts the signal from the loop to the input of the amplifier. The loop coil is connected in series with an iron-cored reactor, and a capacitor tunes this combination to resonance. Two additional tuned circuits are contained in two following stages of the amplifier.

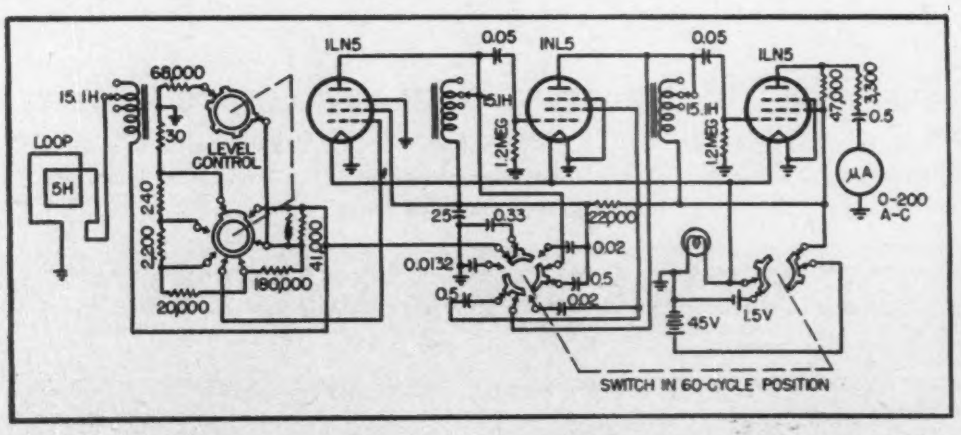
A step attenuator which changes the gain approximately 3 to 1 between adjacent taps is connected between the first tuned circuit and the grid of the first amplifier tube so that amplifier overload does not take place, provided the meter pointer is kept on scale.

Stability

The iron-cored inductances are designed to eliminate changes in inductance as the signal input level varies. This insures that the circuits will remain tuned to the desired frequency regardless of input signal levels. The three tuned circuits provide selection to either of two desired tracing frequencies, 60 or 300 cycles. The sensitivity of the overall instrument is such that good readings are obtained at 10 feet from unshielded 300-cycle currents of 0.0002 ampere or less. When the frequency selector switch is placed in the 300-cycle position, the response to 60-cycle pickup is down approximately 1,000 to 1.

One effect of feeding the faulted circuit with a capacitor is to produce a high percentage of harmonic currents. The equipment is sharply tuned to one of the harmonics for discriminating against signals resulting from nearby circuits carrying normal currents. A second effect of the capacitor feed is to limit the flow of current in the faulted circuit to a safe value. A protective fuse is used with the capacitor, which may be a 15-kva phase-correcting type.

The detector may also be tuned to any frequency not harmonically related to 60 cycles, for use with a special tracing signal generator such as a buzzer or tone generator. According to the manufacturer, Raytron, Inc. of Jackson, Michigan, underground cables can also be checked for faults provided that the fault is broken down to a low resistance by the capacitor feed method, and the tracing current does not flow along the sheath to low-resistance grounds past the fault. In such cases, the signal is followed above ground with the loop and locator.



Circuit of low-frequency amplifier for tracing fault currents on power transmission lines

Supersonic Flaw Detector

During the war, the Reich Government offered a prize for a method of testing for faults in metals that cannot be tested by x-ray or magnetic methods.

These faults are in the nature of "doubling" that occurs when metal is being rolled, as a result of bubbles that existed in the metal before rolling began. With so much sheet aluminum alloy being used in aircraft manufacture it was obviously important that flaws should be detected before flight.

One method of doing this is to pass high current through the test sheet and to measure the voltage drop between various points. This method is workable but the accuracy depends very much on surface conditions.

The method eventually adopted by the Nazis employed a quartz crystal operating at a frequency of one mc as a generator, with the frequency wobbled 100 cycles to avoid standing waves in the test sheet or between the transmitter and receiver.

The vibrations pass from the transmitter through a metal block,

To avoid damage from Oxidation . . .

protect with NITROGEN

LINDE Nitrogen provides an ideal means of protection against oxidation and corrosion by air. For packaging dehydrated foods; for deaerating, processing, storing and packaging fats and oils of all kinds; or for providing an inert atmosphere, free of impurities, for the complete protection of practically any material susceptible to oxidation, use LINDE Nitrogen.

LINDE Nitrogen is 99.7% pure, but is also available bone dry and at higher purity for special applications. It is supplied as a compressed gas in cylinders containing 224 cu. ft. each, or in bulk in tank-truck and tank-car lots as a liquid which is converted into gaseous nitrogen as required. LINDE Nitrogen in bulk offers remarkable savings in cost and eliminates cylinder handling.

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Season's Greetings

from

CORWICO

We pause from the hectic business of delivering Wire . . . to deliver a few words of sincere thanks to our friends for the splendid co-operation we have received from all hands in 1946. A really GOOD 1947 to all!

CORNISH WIRE CO., INC.

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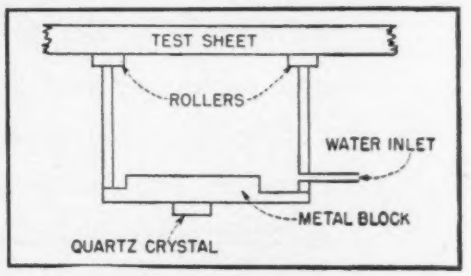
so as not to expose the quartz crystal to water, and thus simplify the insulation problem. Water is admitted to the test chamber by the inlet and is allowed to escape where the chamber makes contact with the sheet being tested, by means of rollers. These rollers maintain the gap constant at 0.5 mm and also facilitate movement of the transmitter.

The continuously flowing water maintains good acoustic contact, even during motion of the sheet, by not permitting air to enter and form bubbles.

Receiver

The receiver is somewhat similar to the transmitter, acoustic contact being again maintained with water,



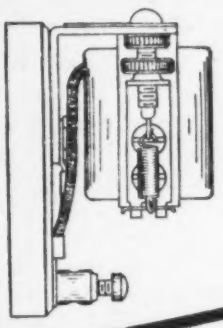
Transmitter unit of the supersonic flaw detector for sheet metal

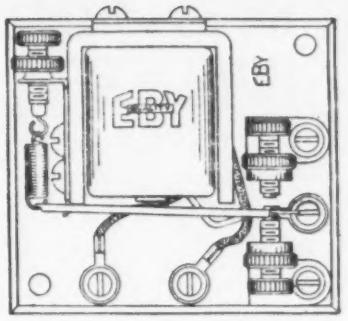
except that there are two outlets, one at the test sheet and one in the walls of the chamber, so that bubbles formed in the chamber may escape. This is necessary because the main opening is very small in the case of the receiver.

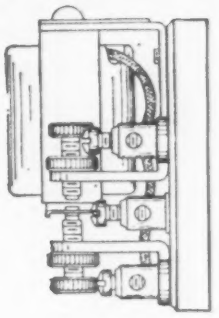
The transmitter and receiver were mounted on long tongs and were pressed into contact with the test sheets by hand or by springs. The apparatus was apparently successful and even rapid movement across the sheet did not interrupt contact. Tests, however, showed that an air gap between the work and the transmitter or receiver was very serious and even one of 10^{-4} mm caused a 99 percent drop in transmission, hence the necessity for avoiding air bubbles. Rust or slag also caused a drop but not so much and since the metal tested would generally be smooth the apparatus was probably very useful. —J. H. J.

Resin Adhesives for R-F Heating

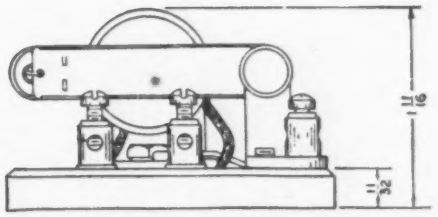
IN DIELECTRIC heating for gluing of wood, the molecular friction will

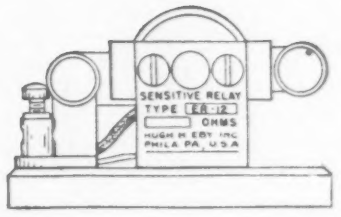


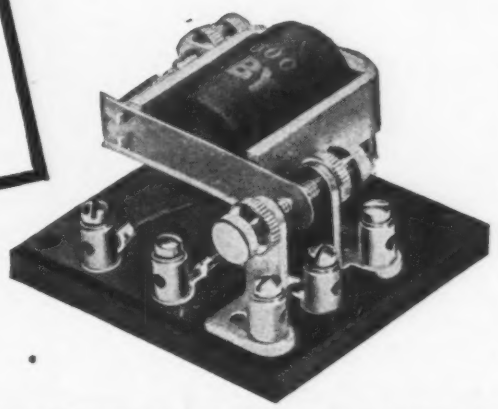


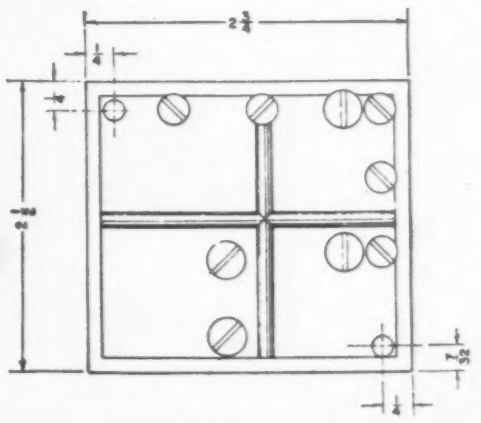


EBY Sensitive RELAY









APPLICATION:

The EBY sensitive relay is designed for direct current (full or half-wave rectified) control circuits where the available power for operation is relatively small. Its low power consumption for positive operation makes it ideal for installation in photoelectric control equipment, vacuum tube amplifier circuits and to protect delicate contacts of sensitive control instruments.

MAGNETIC CIRCUIT:

The EBY sensitive relay, because of the advanced design of the armature, and by the use of a high quality, special steel alloy in the magnetic circuit, has the outstanding features of low power requirement for positive action and its unusually high speed of response.

COILS:

The EBY sensitive relay can be supplied with five different coil sizes covering most of the operational needs in sensitive relay control applications. The standard coil values are: 300, 1000, 2500, 5000 and 10,000 ohms resistance. The relay is rated at 11.25 milliwatts for positive operation; however, it can be adjusted for less when needed. The coils will safely carry 2 watts.

CONTACTS:

Contacts, single-pole, double throw, are of coin silver and are rated to carry 2.5 amperes at 115 volts A.C., or 0.5 amperes at 115 volts D.C. The contact air gap and spring tension are adjustable for critical applications.

BASE:

Molded phenolic.

HUGH H.
EBY
INCORPORATED
18 W. CHELTEN AVE.
PHILA. 44, PENNA.

ELECTRONIC REGULATED POWER SUPPLIES

Precision *Accuracy*

IMMEDIATE DELIVERY

Performance

Specifications:

Input: 115 V. 50-60 cycle.
Regulation: Less than 1/10 volt change in output voltage with change of from 85 to 145 V.A.C. input voltage and from NO LOAD to FULL LOAD (over very wide latitude at center of variable range.)
Ripple: Less than 5 millivolts at all loads and voltages.
Fits any standard 19" rack or cabinet.
TYPE A: Variable from 210 to 335 V.D.C. at 400 M.A.
TYPE B: Variable from 535 to 915 V.D.C. at 125 M.A.
Designed by one of the foremost electronic communication laboratories in the country; constructed by its equally noted associate company; and built for the U. S. Army as Power Supply RA-57-A to be used in conjunction with the microwave RADAR set SCR 547. Equipment was never used and was obtained in their original packing crates.
Adapted to civilian use by mounting on 12¼" x 19" panel, black crackle finish, and installing milliammeters, voltmeters, fuses, switches, pilot lights, terminals, power cords, and all other necessary auxiliary items.

Construction Features:

Weston Model 301 (or equal) Milliammeter and Voltmeter.
Separate switches, pilot lights, and fuses for FILAMENT AND PLATE VOLTS.
All tubes located on shockmount assemblies.
Fuses mounted on front panel and easily accessible.
Can vary voltage by turning small knob located on front of panel.
Can easily modify unit from positive to negative output voltage by changing two leads.
All individual components numbered to correspond with numbers on wiring diagram.
Rigid Construction: Individual components were designed to withstand the most severe military conditions—both physical and electrical—and were greatly under-rated.

Tube complement, Type A: 2-836; 6-6L6; 2-6SF5; 1-VR150; 1-VR105
Type B: 2-836; 2-6L6; 2-6SF5; 1-VR150; 1-VR105
Overall dimensions: 19" wide, 12¼" high, 11" deep
Net weight: 80 pounds. Shipping weight: 95 pounds.

Some of the current users of these power supplies include nationally known electronic and commuunications measurement laboratories; aircraft, metallurgical and chemical research labs; technical schools; commercial radio, F.M. and television stations; amateurs; civilian RADAR installations; etc.

All units checked and inspected at 150% rated load before shipment.

NET PRICE: Type A: $175.00; Type B: $168.00 F.O.B. Baltimore
Prices subject to change without notice

NATIONAL RADIO SERVICE CO.

Reisterstown Rd. & Cold Spring Lane **Baltimore 15, Md.**

vary with the moisture content and density of the wood, neither of which are entirely uniform, and there will be more or less resulting variation in the heat of the wood. The degree of variation is seldom significant, but should not be overlooked.

It is desirable to keep the heat of the wood below the boiling point of water to avoid internal steam pressure and a temperature no higher than 180 F is desirable. At a glue line temperature of 100 F, Amberlite PR-115, a resorcinol-formaldehyde resin, and Uformite CB-552, a urea-formaldehyde resin adhesive, will attain cure in about 90 minutes; at 125 F, 15 and 25 minutes respectively; at 150 F, 3 and 8 minutes; and at 175 F, one and three minutes.

It is therefore important to regulate the temperature and time to secure an initial grip in the glue joint before heat and pressure are released, since further adequate cure will come from the heat stored in the wood or even at normal room temperatures.

Both resins produce highly water-resistant joints. Bonds made with Uformite CB-552 are adequate for products used indoors and in protected locations, while those made with Amberlite PR-115 are more durable than the wood itself and are adequate for weather exposure and the severe service required for boats and marine structures. Both are made by Resinous Products and Chemical Company of Philadelphia.

Materials Tester

WHEN A BEAM of ultrasonic vibrations impinges on a specimen, the energy of the signal is redistributed by several distinct processes. The three general effects are reflection, transmission, and absorption — analogous to light, heat, or audible sound behavior. However, because the wavelengths involved are comparable to the length of travel in portions of specimens frequently examined, and because ultrasonic transmission is a mechanical phenomenon, certain information about the mechan-

IRON SLEEVE CORES

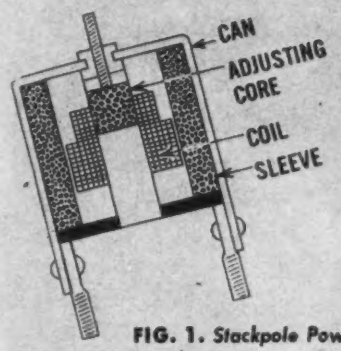


FIG. 1. *Stackpole Powdered Iron Sleeve and Core used for Diode Transformer (I-F); Antenna, Oscillator, or Filter Coils, etc.*

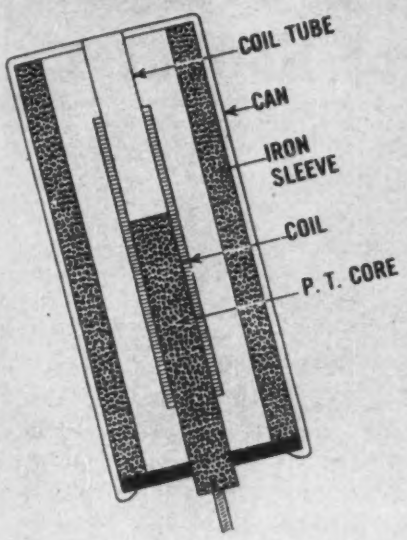


FIG. 2. *Grade SK1 core and powdered iron sleeve (.790 O. D. x 1½" long) used with permeability tuning in auto radio receiver.*

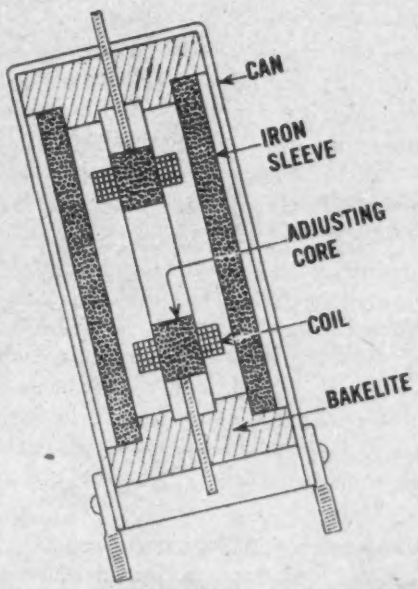
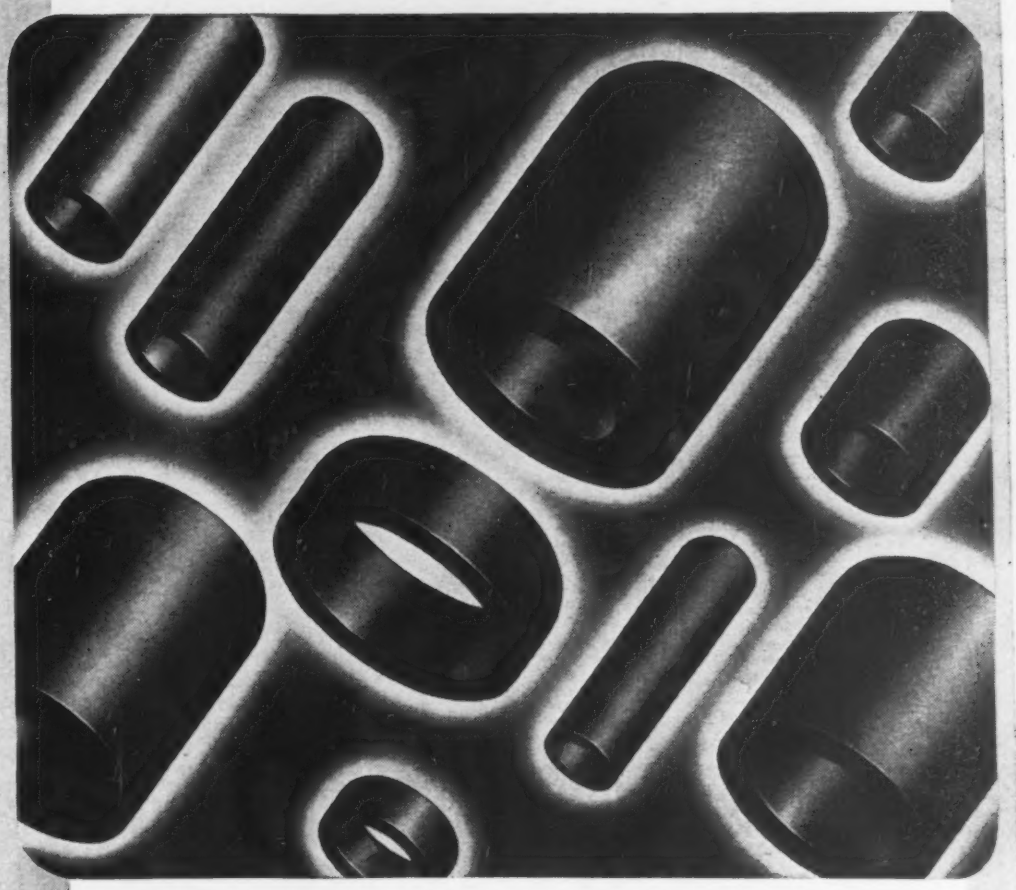


FIG. 3. *Two Stackpole cores and powdered iron sleeve used in a double tuned I-F transformer application.*



The Modern Answer to Better Coils in Less Space

BY USE of Stackpole Sleeve Cores, much smaller cans *of any material* may be used to provide Q that is equal to or better than that of conventional coils and cans. Thus they pave the way to an exceptionally high order of tuning unit efficiency in greatly reduced size. A few of many design possibilities are indicated in the accompanying sketches.

Beside supplying additional electrostatic and electromagnetic protection over that provided by the can alone, sleeve cores result in making the can itself smaller, less critical and less costly. Inexpensive die cast lead cans, for instance, may be used instead of aluminum. In some cases, it may not even be necessary to use a can.

STACKPOLE CARBON COMPANY, ST. MARYS, PA.

EXPORT: Stackpole Carbon Co., 254 W. 34th St., New York 1, N. Y., U. S. A.

STACKPOLE

ELECTRICAL BRUSHES AND CONTACTS (*All carbon, graphite, metal and composition types*) • RARE METAL CONTACTS • WELDING CARBONS • BRAZING TIPS AND BLOCKS • PACKING, PISTON, AND SEAL RINGS • CARBON REGULATOR DISCS • MOLDED METAL COMPONENTS, ETC.

NEW SOLDERING GUN
with adjustable tip
FOR TOUGH JOBS

TIP ADVANTAGES

High heat produced in loop type tip by induction principle gives speed and flexibility to soldering with the new gun type Speed Iron. Ideal for intermittent operation on maintenance and radio service work.

Available at your radio parts distributor or write direct for descriptive bulletin.

- ★ 115 Volt 60 Cycle 100 Watts
- ★ Built-In Light Weight Transformer
- ★ Intermittent Operation With Trigger Switch
- ★ Can't Overheat or Burn Out
- ★ Tip Heats And Cools Fast
- ★ Impact Resisting Case
- ★ Soldering Heat In 5 Seconds

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WELLER MFG. CO. · Easton, Pa.

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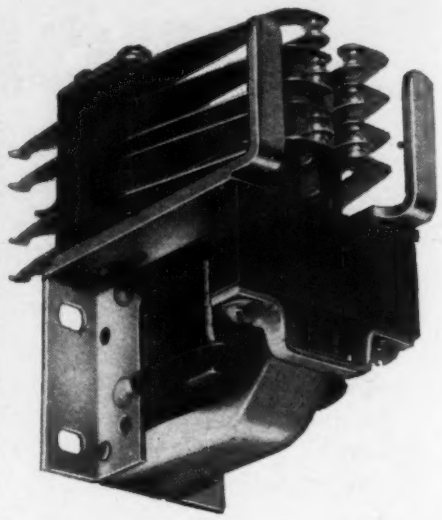
ON YOUR NEXT HOLIDAY

THAT IS IF VERY VERY EXPENSIVE HORN LOADED LOUD SPEAKERS INTEREST YOU

(for indoor P.A., Laboratories, monitoring, or the home)

WE ARE ONE OF THE SMALLEST FIRMS IN THE TRADE
NOT YET IN POST WAR PRODUCTION

DON'T WRITE NOW—JUST REMEMBER THE FULL NAME
VOIGT PATENTS LTD.



A PROVED relay for NEW uses

Originally developed for our Vehicle-Actuated Traffic Control Systems, the AC2 relay is now generally available. Fast-acting, compact, built to handle up to ten million operations a year. Clean operation of as many as ten sets of contacts on each relay, with circuit closure of as little as .010 seconds, is provided for on this precision instrument.

Even where insulation resistance in excess of 300 megohms is required after long service, the AC2 relay assures it through a method of encasing each individual contact spring in phenolic insulation.

All connections at rear, including coil connections, make the AC2 well adapted to vertical rack mounting. Drilled with four mounting holes for No. 8 screws. Centers $1\frac{3}{16}$" horizontal x $1\frac{5}{16}$" vertical.

Coils for 115 volts, 60 cycles, and 12 volts, 60 cycles, and pure silver contacts $\frac{5}{32}$" diameter (rated 5 amps. 115V AC non-inductive) and $\frac{7}{32}$" diameter (rated 10 amps. 115V AC non-inductive) are standard. Other contacts and coils can be supplied on special order.

Overall width $1\frac{3}{4}$". Relay extends $2\frac{7}{16}$" forward and $\frac{9}{16}$" backward from mounting surface. Overall height $2\frac{3}{4}$" from bottom of armature to top of vertical contact guards. This height will accommodate 4 average contact assemblies, 2 in each pileup. Each additional contact assembly adds approximately $\frac{1}{4}$" to the overall height.

Our Engineering Department can be of valuable assistance to you in adapting this relay to your present products or your new designs. Write us your problems and requirements.

AUTOMATIC SIGNAL DIVISION
Eastern Industries, Incorporated
100 Regent Street
East Norwalk, Connecticut

More and More Users of Extruded Vinyl Tubing are STANDARDIZING on NATVAR #400

Here's Why:-

Most users, to make sure that they get the right tubing for a particular job, run tests on the various extruded tubings available to find out whether they are suitable. For some applications, heat resistance is of primary importance. For others, it may be tensile strength, high dielectric, oil resistance, low moisture absorption, or a combination.

Before Natvar #400 was available, it was often the practice to stock several different types of special purpose tubings. This is no longer necessary. Test reports show that Natvar #400 is able to hold its own on practically every count for which a special purpose tubing might be considered.

One of the largest electrical manufacturers reports:

> This tubing has been used in radio transformer construction here at ——— for some time, and it has been found satisfactory ... A comparison of our results with those of the supplier is very favorable ... One peculiar characteristic of this material is the manner in which it behaves after immersion in hot transformer oil. A sample before immersion gave a tensile strength of 4140 psi, and after immersion a tensile strength of 6890 psi. ... The sag test which was conducted in this investigation was more severe than is usually conducted on materials of this type. Nevertheless, this tubing performed remarkably well under these conditions ... A copy of this report is being sent to the various division engineers for review.

Another large electrical manufacturer reports:

> MATERIAL TESTED: #400 Natvar Tubing, Flexible Extruded Vinyl.
>
> Effect of Heat: Like any other plastic, this material softens upon heating, but at 125° C. it does not flow or sag. It remains unaltered, except for darkening, after a week in the drying oven.
>
> Effect of Oil: In oil at 100° C., the tubing does not swell, soften, dissolve or harden. It remains unchanged except for a change in color.
>
> Effect of Compound Treatment: The tubing flatted out due to heat, but was still pliable when removed. It is satisfactory for this application.
>
> Dielectric Strength: Dielectric Puncture Tests, using a metal rod as inner electrode, and copper ribbon as outer electrode, gave the following results (tested in oil at room temperature):

	Short Time	Step-by-Step
As received	19,000 v=725 v/mil	17,600 v=691 v/mil
Dried 2 days @ 125°C	19,000 v=744 v/mil	16,800 v=667 v/mil
Dried 3 days @ 125°C plus 24 d. in oil : 100°C	26,000 v=1023 v/mil	19,400 v=723 v/mil

Underwriters' Laboratories limitations permit wide use. Natvar #400 is now available for immediate shipment in most sizes, either from your wholesaler's stock or from our own. Write, wire or phone us your requirements.

Excerpts from the E.T.L. report covering tests made on Natvar No. 400 in accordance with A.S.T.M. Standards.

DIELECTRIC STRENGTH—A.S.T.M. D350-43
Average volts per mil: At 28°C—1090
At 85°C— 700
Wall thickness: .0235"

DIELECTRIC CONSTANT AND POWER FACTOR
Dielectric constant at 29°C and relative humidity 60%
At 60 cycles: 8.15
At 1 megacycle: 4.35
Power Factor: At 60 cycles: .056
At 1 megacycle: .064

ARC RESISTANCE—A.S.T.M. D495-42
Average—135 seconds

OIL RESISTANCE—A.S.T.M. D295-43T
"Turbol 10" at 105°C was used. After 15 minutes immersion there was no apparent change in the tubing. After 24 and 48 hours there was no sign of change in the tubing. Three separate tests were made.

HEAT ENDURANCE—A.S.T.M. D350-43
After 7 days at 125°C the tubing did not crack or otherwise fail when bent 180° around a 5/16" mandrel.

TENSILE STRENGTH AND ELONGATION
At 200% elongation: Average 1980 lbs. per sq. in.
At Maximum: Average 2870 lbs. per sq. in.
Total elongation: 350%

LOW TEMPERATURE FLEXIBILITY
After 3 hrs. at minus 30°F specimens were bent around a mandrel 5/16" in diameter. There was sign of cracking or other failure.

FLAME RESISTANCE—D350-43
Burned about ¼ in. in 10 to 15 seconds and then went out. Three tests were made.

EFFECT OF CHEMICALS
Effect of 7 days immersion in solvents at room temperature; average of 3 tests in each solvent:

Solvent	Change in weight Per cent of weight of specimen as received	Change in dimensions Per cent of dimensions of specimen as received Length	Outside diameter	Thickness
5 per cent sulfuric acid	+ 0.41	none	none	none
1 per cent potassium hydroxide	+ 0.83	none	none	none
Petroleum	+ 6.62	+2.6	none	none
Ethyl Alcohol	+ 1.66	none	none	none
Benzol	+21.9	+6.6	+10.9	—24.0

WATER ABSORPTION
Average of 5 tests
Water absorption, per cent by weight of dry specimen 0.63
Soluble matter, per cent by weight of dry specimen 0.01
Total water absorption, per cent by weight of dry specimen 0.64
Change in dimensions: in length none
in outside diameter none
in thickness none

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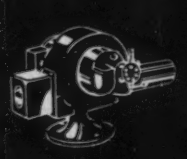

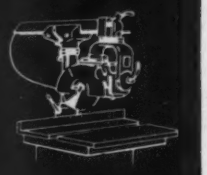

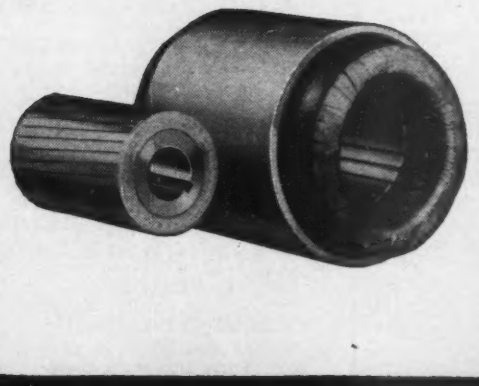

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ical properties of specimens can be obtained.

Reflection is an indication of discontinuities, absorption results from internal porosity, viscosity, etc, and transmission is a measure of the beam energy not dissipated by reflection or absorption in the specimen. The most complete information can be obtained if the specimen can be examined over a wide range of ultrasonic frequencies.

Instrument

The General Electric ultrasonic materials tester provides on the screen of a cathode-ray oscilloscope an instantaneous response pattern of a complete ultrasonic transmission system to a wide band of ultrasonic frequencies. It provides simultaneously an indication on a panel instrument which corresponds to the total ultrasonic energy transmitted through the system.

The materials tester contains a high-frequency signal source which is automatically frequency-modulated over a band of frequencies about 500 kilocycles wide. The response of the transducers, the transmitting medium, and the specimen to these frequencies produces the ultrasonic spectrogram on the oscilloscope screen. Panel controls adjust the generator output, the range of frequencies, and the center frequency.

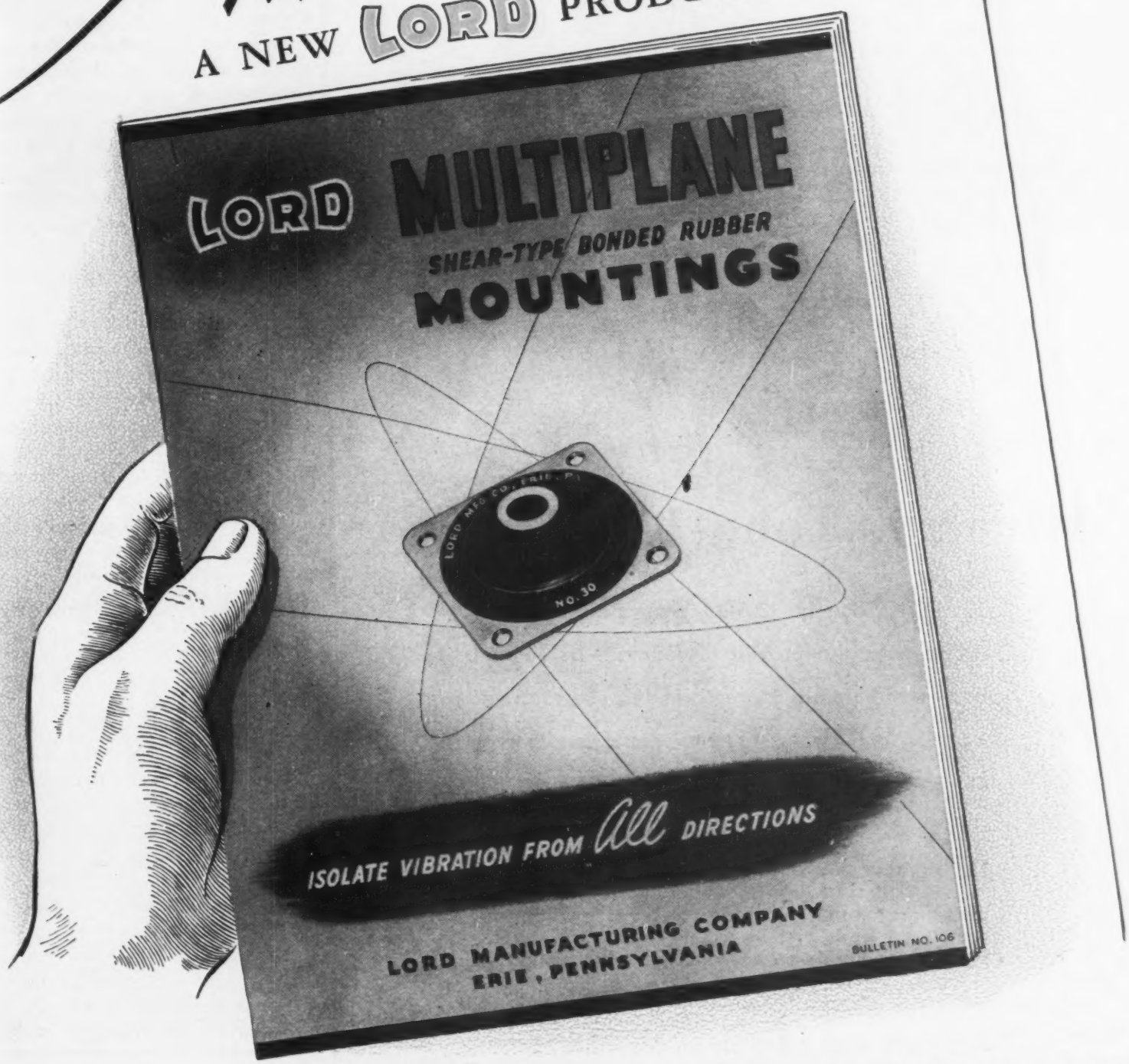
The transducers are resonant crystals sealed for immersion in water. They operate at one megacycle and have a response range of about 200 kilocycles. If other liquids or frequencies must be used special transducers are required.

The receiver is a wide-response type which requires no tuning and operates continuously at maximum sensitivity. Its useful response range extends from 100 kilocycles to two megacycles.

To examine regularly shaped specimens for internal voids, cracks, porosity, and laminations, only the final instrument reading must be considered. Small specimens can be rapidly examined by inserting each between the transducers in the liquid medium and comparing the reading with that for a specimen shown to be sound by x-ray, mechanical breakage, or

ANNOUNCING

A NEW LORD PRODUCT



HERE are the new Lord Vibration Control Mountings which isolate destructive vibration, *regardless of the direction of disturbing forces.* They are called MULTIPLANE (many planes) because they are equally soft in all directions. MULTIPLANE Mountings — made in three sizes, four types, and nine load ratings — are easily applied to most light and medium-weight installations. In your efforts to obtain maximum protection for delicate equipment, or to build smoother, quieter machines, you should investigate the new MULTIPLANE Mountings — the latest contribution to product improvement from "Vibration Control Headquarters."

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sectioning methods. Large specimens can be tested by rotating them between the transducers.

Internal flaws produce measurable decreases in total transmission and a consequent drop in the instrument reading. Because of the very broad response of the tester, small changes in dimensions or placement of the specimen will not ordinarily affect the transmission reading, making it far more versatile than ordinary sharply tuned sonic transmission equipment. On the other hand, these effects if important, will show up on the oscilloscope screen as a change in response pattern.

The instrument reading and response pattern obtained when the transducers are immersed in a liquid depends on two important properties of ultrasonic propagation through the liquid: attenuation and velocity. It is therefore possible to monitor continuously any property of the liquid which significantly changes either attenuation or velocity. These important properties are viscosity, compressibility, and density.

The information obtained can be compared, in terms of the analogy to light behavior, with those of a light meter and a spectroscope. The light meter, similar to the panel instrument of the ultrasonic receiver, indicates the total amount of energy passing from a source through a medium to the meter. The spectroscope, like the oscilloscope of the receiver, shows the distribution of this energy in terms of wavelength. In both examples each type of information may be necessary or useful for a given testing, analysis, or research problem.

FLOCKING electrostatically has been done at General Electric Schenectady Laboratories. 200,000 cloth fibers stand erect, perpendicular to an adhesive-coated backing material, in one square inch of fabric.

A COMPENSATED BOLOMETER at the focus of a 60-centimeter mirror was the basic equipment of a fire-control system for gunnery that was being unpacked by the Germans on the Normandy beach on D Day. It was an alternative for radar fire control if that were made useless by jamming.

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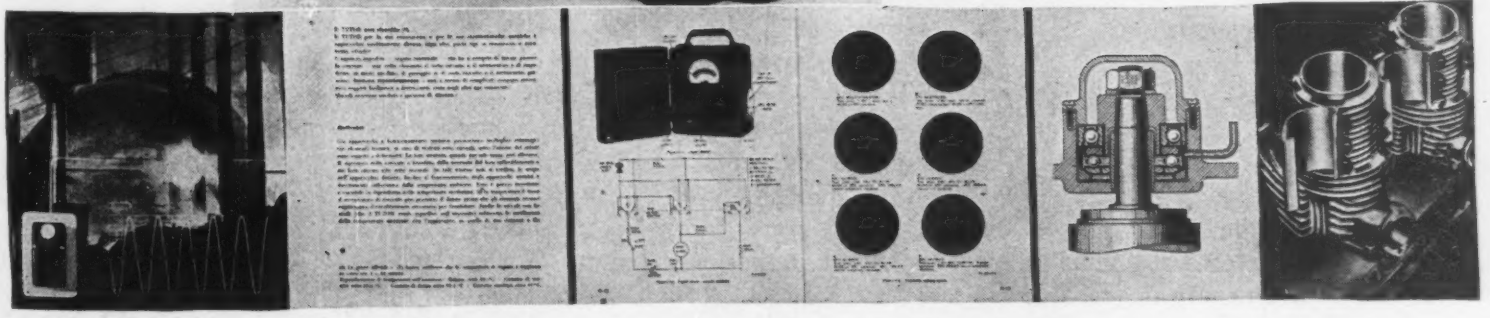

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THE ELECTRON ART

Edited by FRANK ROCKETT

Antennas for Circularly Polarized Waves 214
Cosmic Ray Measurements 214
German Industrial Techniques 216
Combined Limiter and Squelch Circuit 222
Miscellaneous U. S. Patents 224
Oxide Coated Cathodes 226
Sources of Infrared Radiation 228
Wideband I-F Amplifiers 232

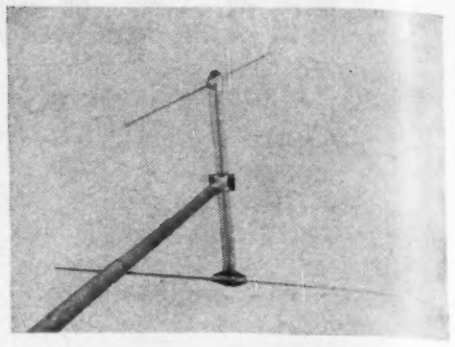

Fig. 3—Array for receiving circularly polarized radio waves

Antennas for Circularly Polarized Waves

TO STUDY THE EFFECTS of polarization on propagation, a transmitter array composed of a vertically polarized coaxial radiator and a horizontally polarized folded dipole loop was used. The vertical radiator was mounted in the center of the horizontal loop which in turn was located at the lower end of the vertical radiator as shown in Fig. 1. When the two antennas are fed

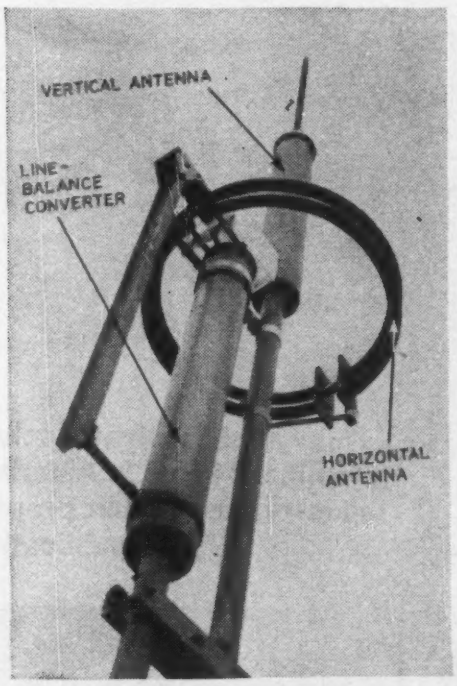

Fig. 1—Combination of horizontal and vertical radiators produces a circularly polarized radio wave

from a common point directly below, the radiated fields of the two antennas are ninety degrees out of phase because of the additional quarter wavelength up to the feed point of the coaxial dipole. This ninety-degree phasing of the two polarizations, together with the equal fields from the two antennas, tends to produce a circularly polarized radiated field.

Figure 2 shows the performance of the array. The field of the array

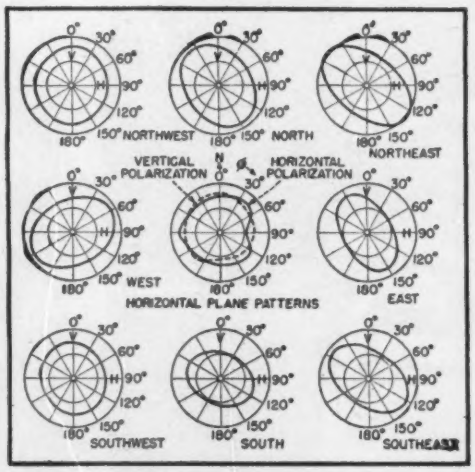

Fig. 2—Pattern at center shows the field intensities of the two components radiated by the array of Fig. 1. Ellipses indicate the polarization perpendicular to the indicated directions of propagation

is elliptically polarized for the most part because the horizontal element radiates with slightly different phases and magnitudes in different directions relative to its center. The field pattern of the horizontal antenna is typical of a loop radiator which approaches a quarter wavelength. The irregularities of the vertical antenna field are probably due to currents flowing on the vertical members of the support.

A receiving array for circularly polarized waves was mounted on a hollow wooden pole. The parallel-wire transmission line ran down the core of the pole. As shown in Fig. 3, the array consists of two half-wave dipoles, one oriented vertically, the other horizontally, and spaced a quarter wavelength apart. The aluminum angles that serve as spacers are the conductors as well and serve to connect the dipoles in parallel. The pole was fastened to the center of the spacers with the transmission line.

Measurements made with this equipment by the United Broadcasting Company at their experimental f-m station W8XUB, Cleveland, Ohio, indicate that if circularly polarized radiation is used, the orientation of receiving antennas for acceptable reception will be less critical than with either horizontally or vertically polarized radiation. It was also observed that outside antennas appreciably improved reception, and that increasing the height of the receiving antenna caused marked improvement in reception, providing that the antenna was kept away from buildings. Mounting the antenna at the peak of the house roof and close to the roof was not as good practice as mounting slightly lower but well away from the house. FCC has made circular polarization optional for f-m broadcasters.

Cosmic Ray Measurements

MEASUREMENTS made with telescopes consisting of Geiger-Mueller tubes between lead plates that were carried in the heads of rockets traveling 100 miles into the atmosphere (Aug. 1946, p 264) indicate that cosmic-ray showers are 300 times more numerous in the upper atmosphere than at ground level. Peak concentration of secondary particles (mesotrons) generated by cosmic rays is at 100,000 feet, high enough for cosmic rays not to have

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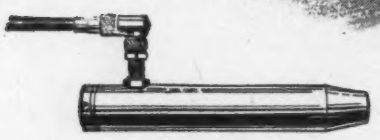

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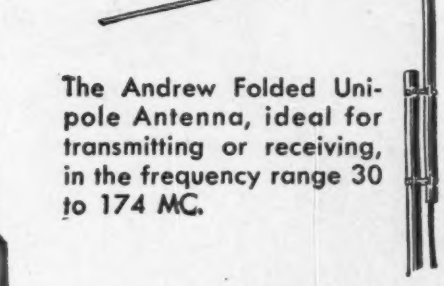

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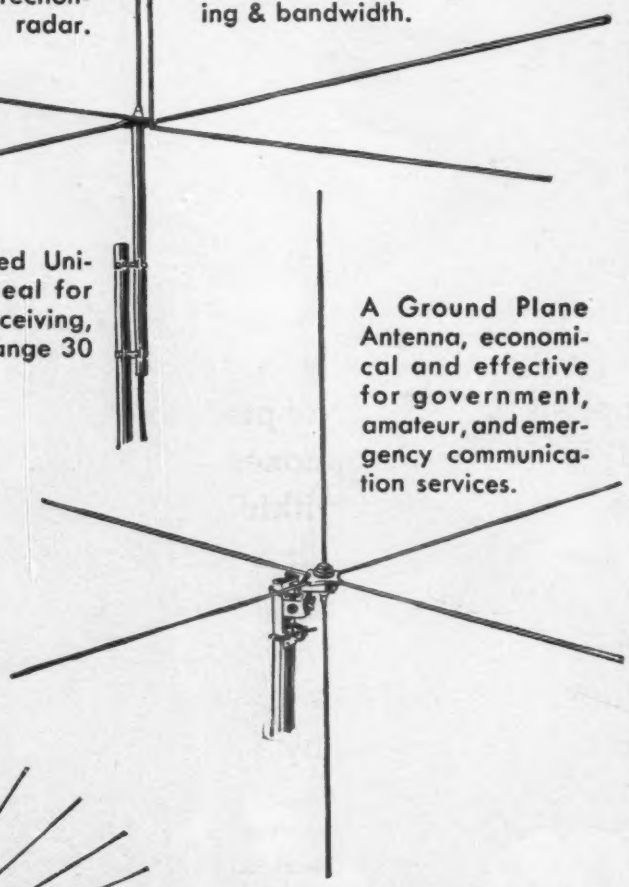

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been filtered out by the atmosphere, but low enough so there are sufficient atmospheric particles with which to collide.

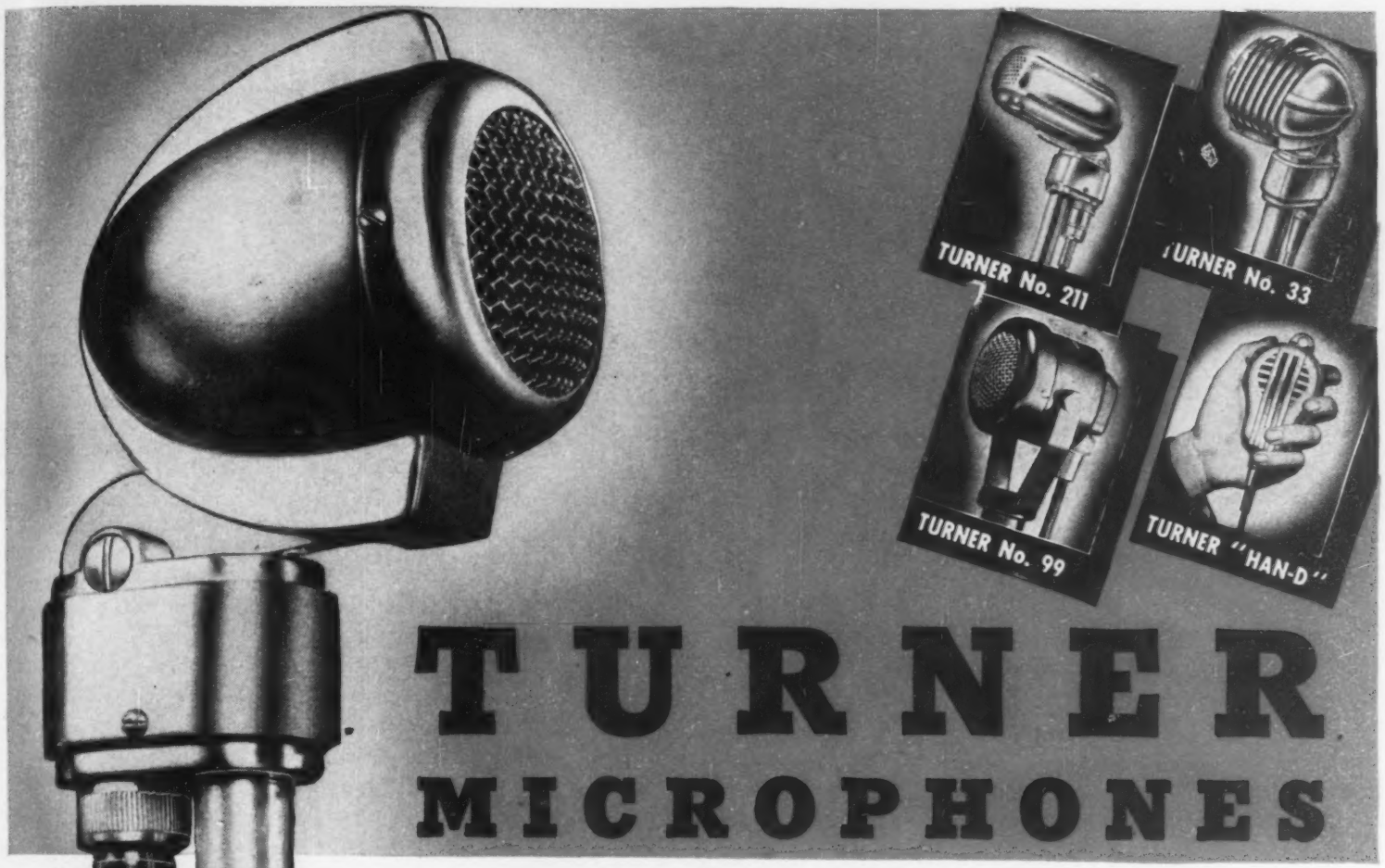
Equipment used for these measurements, designed by scientists of the Applied Physics Laboratory of Johns Hopkins University and produced by the Wilmotte Manufacturing Co., consisted of two sets of detectors, the telescopic pair sensitive only to particles coming from a single direction with sufficient energy to trip all counters, and others to indicate charged particles accompanying radiation striking outside the telescopic set. Data were recorded both on a slowly rotating steel drum in the rocket, and on the ground from telemetering signals. In both cases, amplifiers were used to raise the signals to a useful level. The Geiger-Mueller tubes were of the same type used in the Bikini atomic bomb tests. Results will enable scientists to understand more fully the nature of atoms and cosmic rays.

German Industrial Techniques

REPORTS of Allied technical missions investigating German factories can be seen at the Department of Commerce, Office of Technical Services, Washington, D. C. Some of these reports have been reviewed (July 1946, p 200); reviews of others are presented below. Of these reports, three are available from the Department of Commerce, Office of Publication Board; of those previously presented, C-8 is PB-418, and C-58 is PB-1292; C-51 below is PB-2609. Manufacture of metalized paper capacitors, previously reported, is described in PB-421.

Detectors and Resistors

Silicon detectors (Bartel cells) that are less sensitive to shock than Allied detectors were manufactured by depositing silicon crystals from silicon tetrachloride on a carbon rod within a quartz tube using aluminum as a binder in a furnace at 800 C. An electrode of nickel or tungsten of 0.1 mm diameter was made to press lightly on the silicon crystals. No ad-



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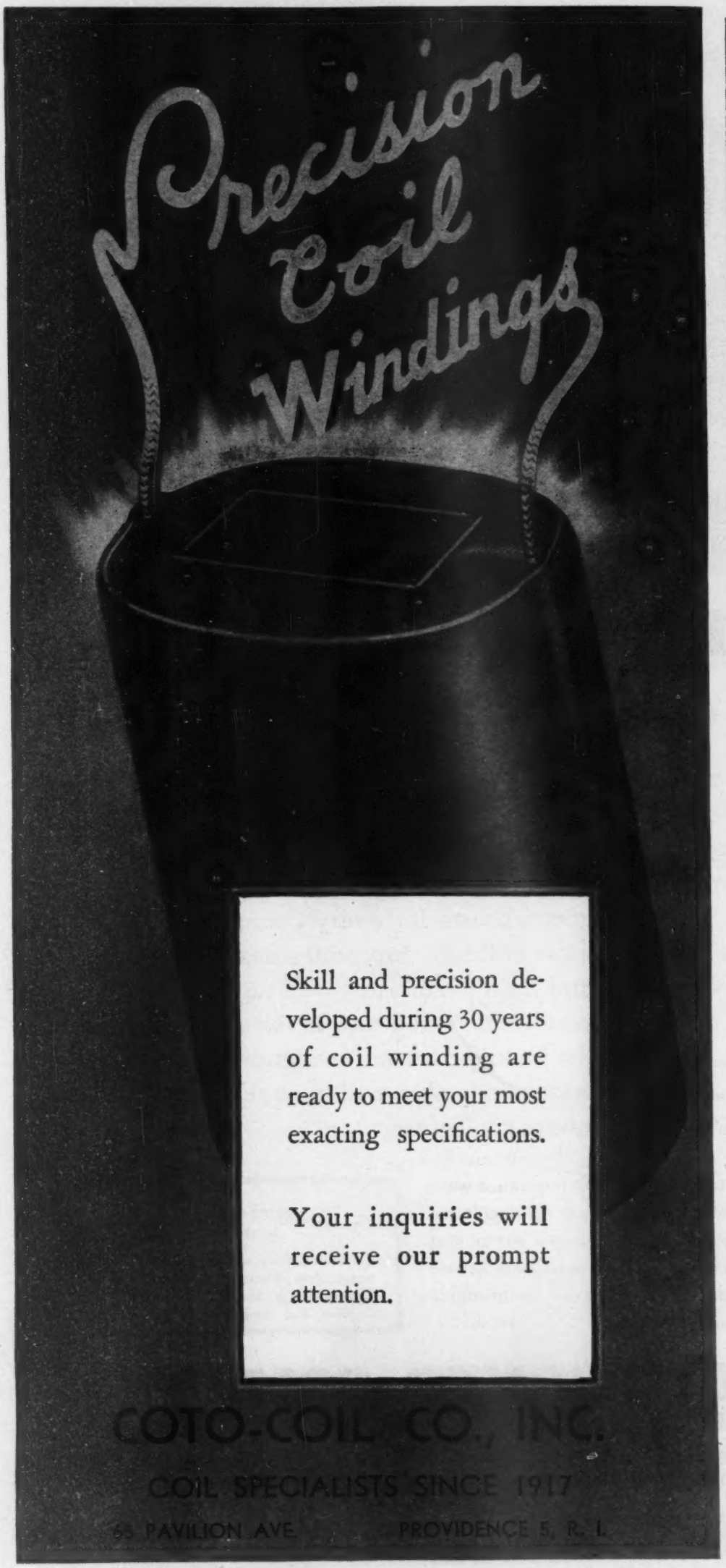
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justment was made. The completed detector withstands an acceleration of ten times that of gravity and a potential of ten volts. Improved fluorescent screens were also made (C-12: 1 p).

Crystal detectors were also made from a mixture of magnesium and titanium powders pressed and heated (C-19: p 1). Captured Allied silicon detectors were analysed by the Germans for impurities and found to contain traces of aluminum and beryllium which, as German experience had indicated, improved their rectifying properties. Translucent conductive layers were produced as bolometers used in intensity measurements of centimeter waves (C-37A: 4 p).

Carbon resistors were formed on unglazed porcelain which was first inspected for freedom from surface pits, foreign particles, and size—the latter done automatically. These cores were sand cleaned, washed, and carbonized. Spiral grooves for high-resistance resistors were cut with a resin bonded wheel, the last portion of the spiral being cut slowly with the resistor in a bridge to obtain the desired resistance. Resistors were sorted automatically at 12,000 per hour into six groups each with twenty subclasses (C-43: 1 p).

Sound Recording

The magnetophone, a magnetic sound recorder using plastic tape, was widely used throughout German radio and broadcasting both military and industrial. Large libraries of tape recordings were provided at broadcasting studios. The tape has low noise, is run at 80 cm per second for recording frequencies up to 10,000 cps, is 0.05 mm thick and 5.0 mm wide. The recording material is magnetic ferric oxide dried onto the tape. The surface of the tape is run in contact with electromagnetic armatures having very narrow slots running cross-wise to the tape motion. Tapes are wiped to reduce noise and erase previous signals by high frequency. High frequency currents are fed with the program material to the recording head to overcome hysteresis effects and improve linearity. For office use the entire recording-reproducing equipment was built into a volume about the capacity of a console radio cabinet and designed to

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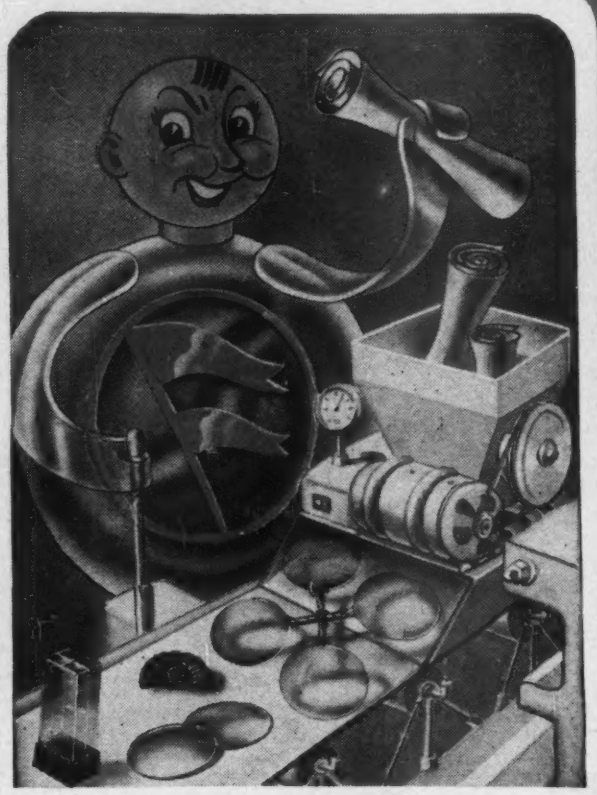

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require no special knowledge or skill to operate (C-59: 13 p).

Toneschreiber models using paper tape as backing for the magnetic coating were developed for portable and field use. Operation and construction are reported in detail (C-59: 12 p).

Ceramics

CAPACITORS OF REDUCED size were produced by developing materials of high dielectric constants, high permeability, high or low insulation, plus negative temperature coefficients. For high dielectric constant, titanium dioxide in one of its crystalline forms was the basic constituent. A high-dielectric ceramic mixed with oil to form a paint was applied to submarines to reduce reflection of radar signals. For complete absorption of the incident wave, high permeability of the coating was also sought. A one-to-one mixture of ceramic powders in triacetate produced a flexible dielectric suitable for winding small foil capacitors (C-51A: 7 p).

Ceramics having at the same time high dielectric constant and very small electric phase angle were produced. Dielectric constants up to 500 were obtained in manufacture. Ceramic bonds for ferromagnetic cores were also used (C-51B: 7 p).

Ceramics were used as spacers and supports in vacuum tubes as substitutes for mica. High voltage capacitors were made of vitrified ceramic bodies. Low-voltage tubular ceramic capacitors were also produced. After firing, the thin-walled tubes are nicked with a rubber bonded silicon carbide wheel and broken by hand to length. Ceramic discs are used as rotors in trimmer capacitors. Metal pins were fastened into ceramic bodies by placing the pin in a hole with a serrated edge, heating the pin with a spot welder and pressing the pin into the ceramic body. Pins mounted this way can not be removed without breaking the ceramic. Metal layers are fired onto ceramic bodies and built up by electrolytic deposition. (Metallized ceramics used as anodes in tubes, are vacuum sealed to the metal case.) Vacuum tight bonds were produced between a Steatite body and iron for ring joints (C-63: 31 p).

Some small grids were made by

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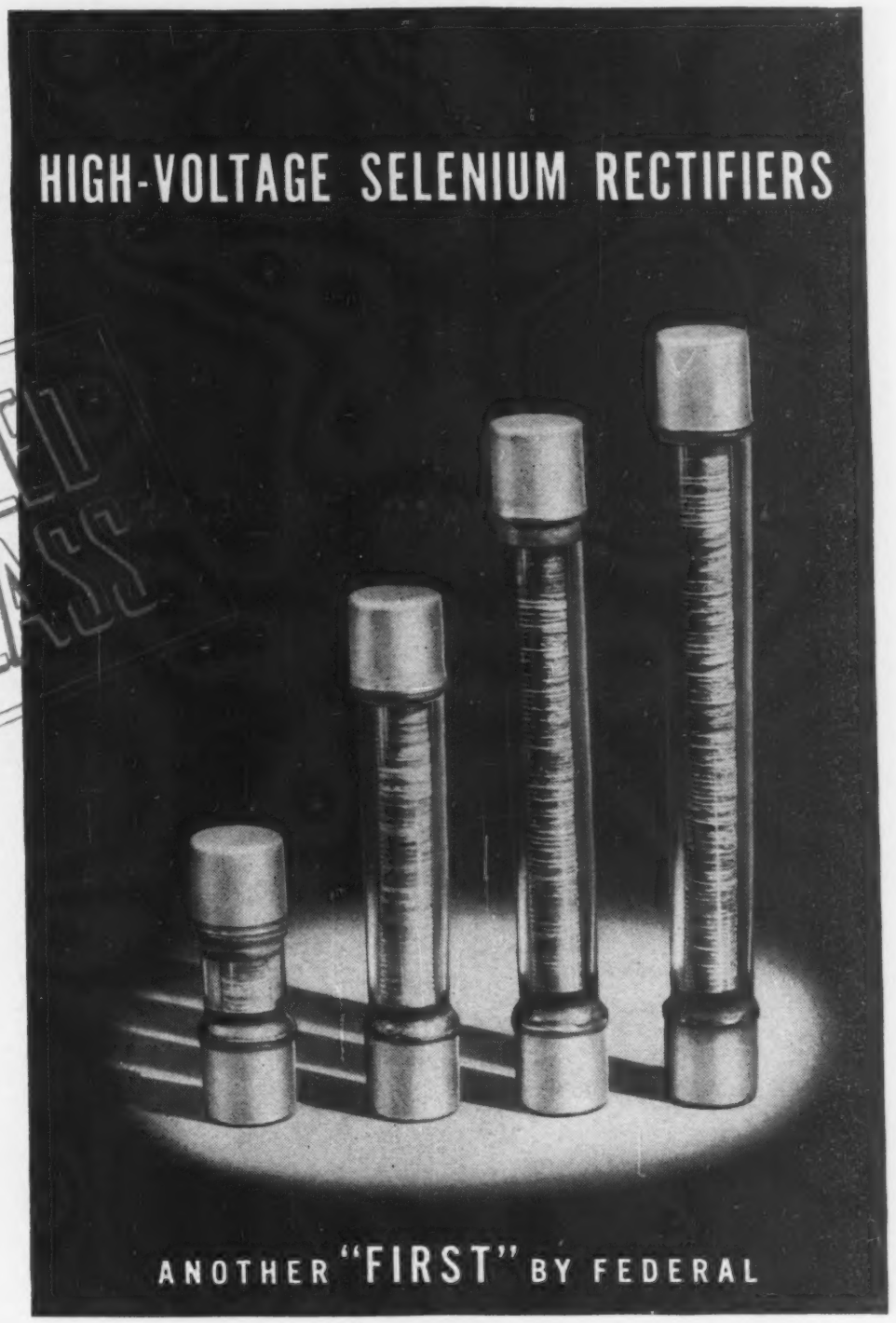

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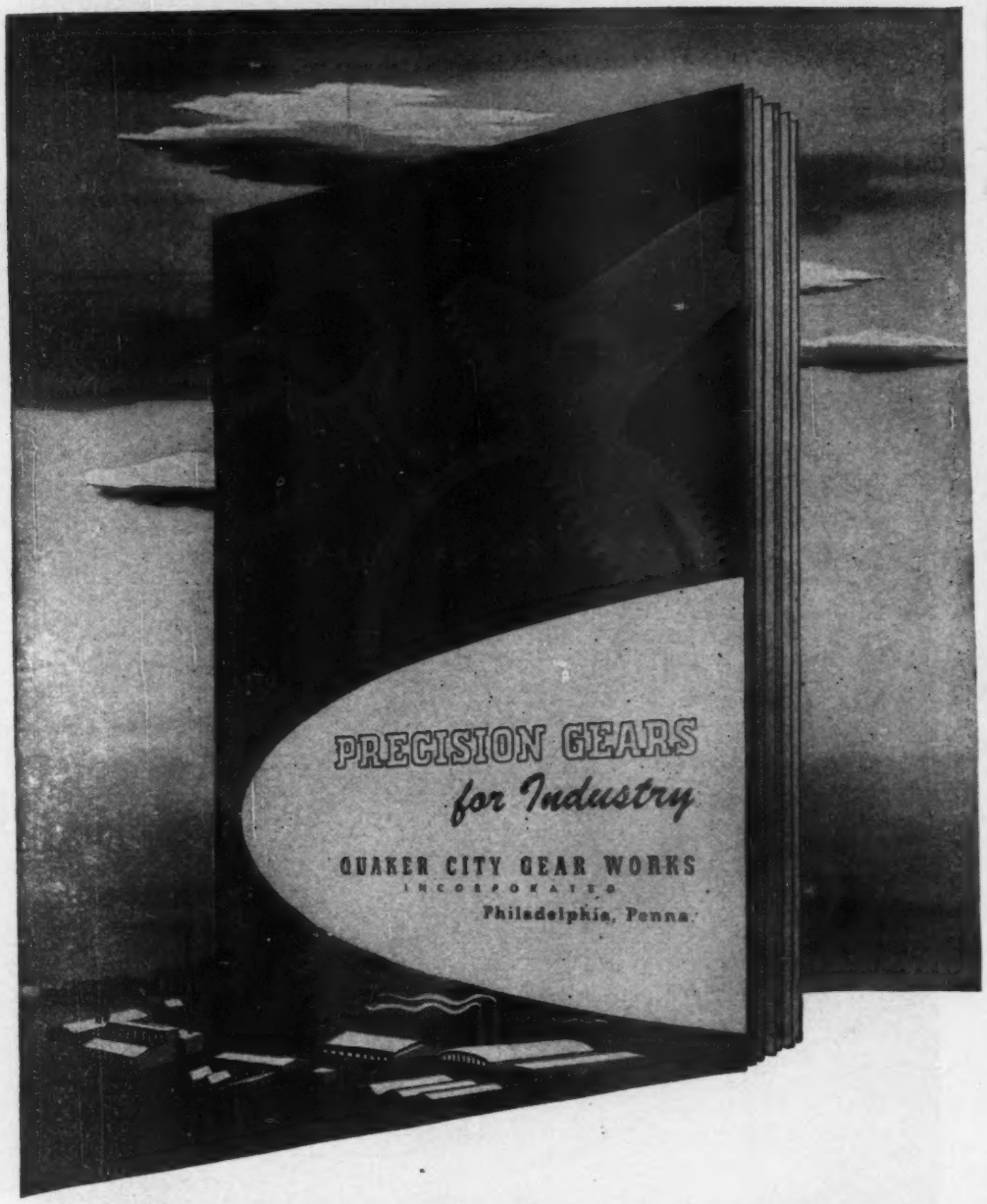

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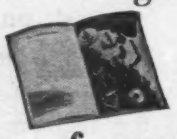
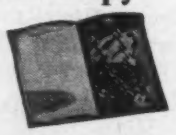
A new informative booklet on gears. It has illustrated sections  **on practically every known form of gearing, together with** **many reference tables and formulas. Write for your copy today on your company stationery.** 

Quaker City Gear Works
INCORPORATED

1910 N. Front Street, Philadelphia 22, Pa.

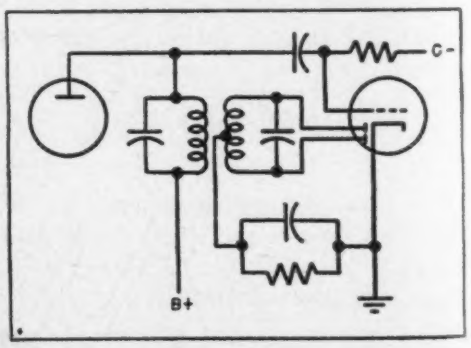
welding instead of notching and swedging. Tantalum was produced in evaculated electric furnaces, cooled and cold worked into wire. It was found that every time the cross section was halved, the wire had to be heated in vacuum to remove the hardness produced by working (C-46: 1 p).

Electron discharge from closely spaced cold electrodes was investigated by German scientists. Results of experiments, which are given in a translated paper written by the experimenter, indicated that under highly controlled conditions electron discharge is produced by potential gradients approaching those required by the theory of Schottky. An interferometer for measuring electrode spacing, vacuum-tight diaphragm for coupling to movable electrodes from outside the evacuated tube, and high-vacuum techniques are described (C-64: 25 p).

Combined Limiter and Squelch Circuit

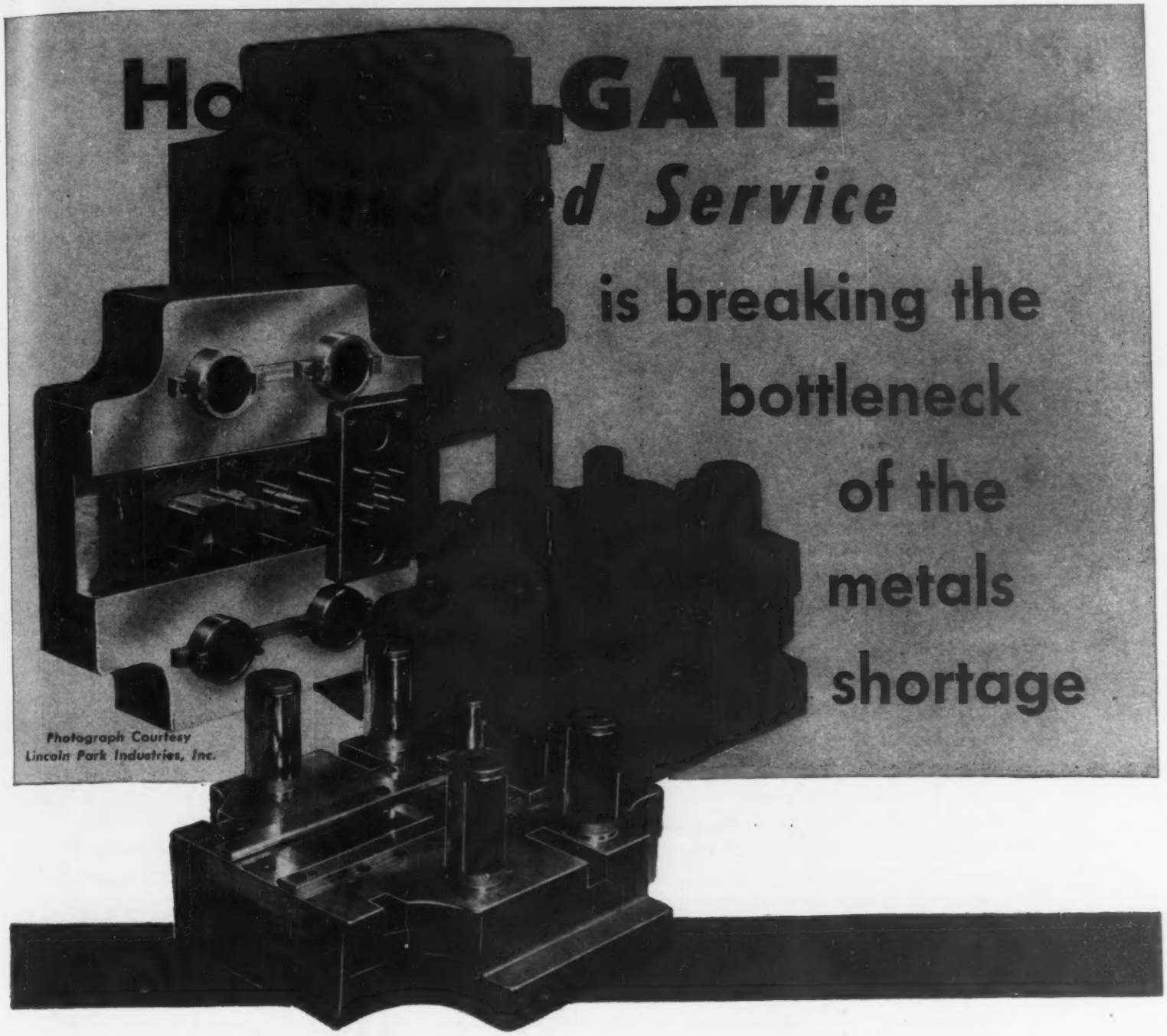
U. S. Patent No. 2,405,845
Granted to ERNEST R. PFAFF
Assigned to Admiral Corp.
Chicago, Ill.

A VOLTAGE LIMITER for removing high-amplitude portions from a frequency-modulated signal consists of a center-tapped transformer magnetically coupled to the normal amplifier coupling transformer, in addition to the usual coupling from the anode of one amplifier tube to



Diode loads transformer on peaks

the grid of a second amplifier tube. The center-tapped transformer is a part of the circuit shown in the accompanying diagram. The resistance-capacitance circuit biases the anodes beyond conduction for normal signal amplitudes, but in



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the presence of a signal of exceptional amplitude, the anode circuit conducts. The added loading of the conducting diodes on the internal resistance of the first amplifier reduces the available voltage to the second amplifier. Thus for proper operation, the first amplifier should have high internal resistance (poor regulation). In addition to its use as an f-m limiter, the circuit can be used to remove r-f noise in a-m receivers if it has a very long time constant.

Miscellaneous U. S. Patents

VARIATION of anode-cathode current of a vacuum tube is produced by movement of an external member of a beam-forming structure. Movement of the external beam-forming electrode deflects the electron beam relative to the receiving anode to produce current variation. (2,376,-882, Space Discharge Device, Hyman Olken, May 29, 1945).

Means of controlling the ignition system or guarding against pilot-light failure of burners are provided by several electronic techniques such as d-c bias and phase shift control of the rectifiers that operate control relays. Operation of the bias or phase shift networks depends on the rectifying impedance of a flame which is interposed in a normally nonconducting gap in the control circuit. (2,379,-871, Burner Control Device, Vilynn O. Bean and John M. Wilson, assigned to Minneapolis-Honeywell Regulator Co., July 10, 1945; 2,-379,872, Electronic Control Apparatus, Willis H. Gille, assigned to Minneapolis-Honeywell Regulator Co., July 10, 1945; 2,379,873, Electronic Control Device, Frederick E. Lange, assigned to Minneapolis-Honeywell Regulator Co., July 10, 1945).

Using a cathode-ray tube, a printing high-speed telegraph is obtained. The transmission consists of a series of single pulses for each character. The individual pulses are shifted in phase relative to their normal occurrence position by an amount corresponding to the particular character they represent. At the receiver is a cathode-ray tube having a rotary sweep. In

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2.5	2.5	2.5 V.
10	10	10 V.
50	50	50 V.
250	250	250 V.
1000	1000	1000 V.
5000	5000	5000 V.

Milli-amperes D.C.	Micro-amperes	Ohms	
10	100	0-1000	(12 ohms center)
100		0-100,000	(1200 ohms center)
500		0-10 Megohms	(120,000 ohms center)

(5 Decibel ranges: —10 to +52 DB)

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the path of the beam is a disk around the periphery of which have been punched holes of the shape of the letters of the alphabet and other characters to be transmitted. The electron beam rotates in synchronism with the rate of pulse transmission. When a pulse is received, the electron beam is deflected to pass through the appropriate hole in the stencil plate. The shape of the hole forms the contour of the beam so that it projects the image of that character on a reading screen. Additional means of beam deflecting spreads the sequence of characters apart across the screen. The characters so projected can be photographically recorded if they appear too fast to be recorded otherwise. (2,379,880, High-Speed Telegraph System, Harry A. Burgess, assigned to Bell Telephone Laboratories, Inc., July 10, 1945).

By projecting a strip of light across the picture to be transmitted by facsimile and imaging the illuminated strip on a long, narrow signal-generating screen of an iconoscope, the moving parts of a facsimile scanner are greatly simplified. (2,379,906, Continuous Facsimile Scanner, John V. L. Hogan, assigned to Faximile, Inc., July 10, 1945).

Oxide Coated Cathodes

PULSED OPERATION of vacuum tubes has led to further study into the characteristics of oxide coated cathodes. Under conditions of high pulse currents, cathodes are not operating at equilibrium, as was assumed in developing from statistical mechanics the theory of an impure semiconductor in its solid state to explain cathodic emission. Rather, there is a loss of the cathode coating metals and their oxides from the outside surface accompanied by migration of metals and oxides from the coating interior to the surface, considerable interaction between the coating and the base metal (the exact extent and nature of which is still to be determined, although much light has been shed on the problem), and an interface resistance between coating and base in the form of a crystal compound that appears to behave as do oxide rectifiers; that

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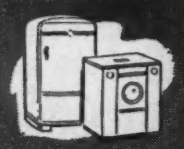

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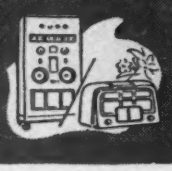

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is, there is a metal (nickel cathode sleave), a blocking layer (crystalline interface), and a semiconductor (oxides of barium and strontium).

Measurements show that this interface resistance behaves like multiple-layer oxide rectifiers, bearing out this supposition. (Oxide Coated Cathode Literature, 1940-1945, John P. Blewett, a review with bibliography of basic research papers on advances in emission theory; The Pulsed Properties of Oxide Cathodes, Edward C. Coomes; A Study of Oxide Cathodes by X-Ray Diffraction Methods, A. Eisenstein; and Studies of the Interface of Oxide Coated Cathodes, A. Fineman and A. Eisenstein, three papers presenting some of the results of studies at the MIT Radiation Laboratory, all in *Jour of Appl Phys*, Aug. 1946, see also a thesis paper by Harold Jacobs, *Jour of Appl Phys*, p 596, July 1946.)

Source of Infrared Radiation

SIGNALING by modulating the intensity of a light beam has been used for ship-to-ship and ship-to-shore and similar communication. For privacy, such communication is frequently made over beams of infrared radiation. Infrared radiators are also used in infrared spectrometers and burglar alarms.

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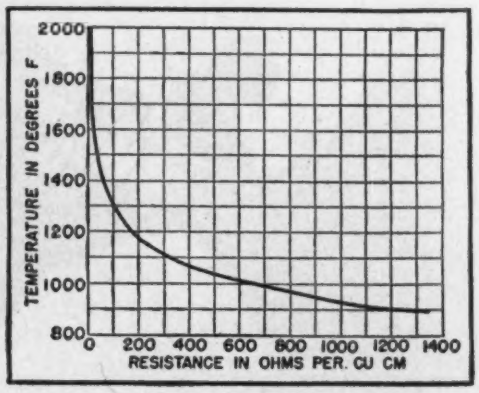

Steatite has a negative specific resistance characteristic, and thus at high temperatures it is a conductor that can be modulated at voice frequencies

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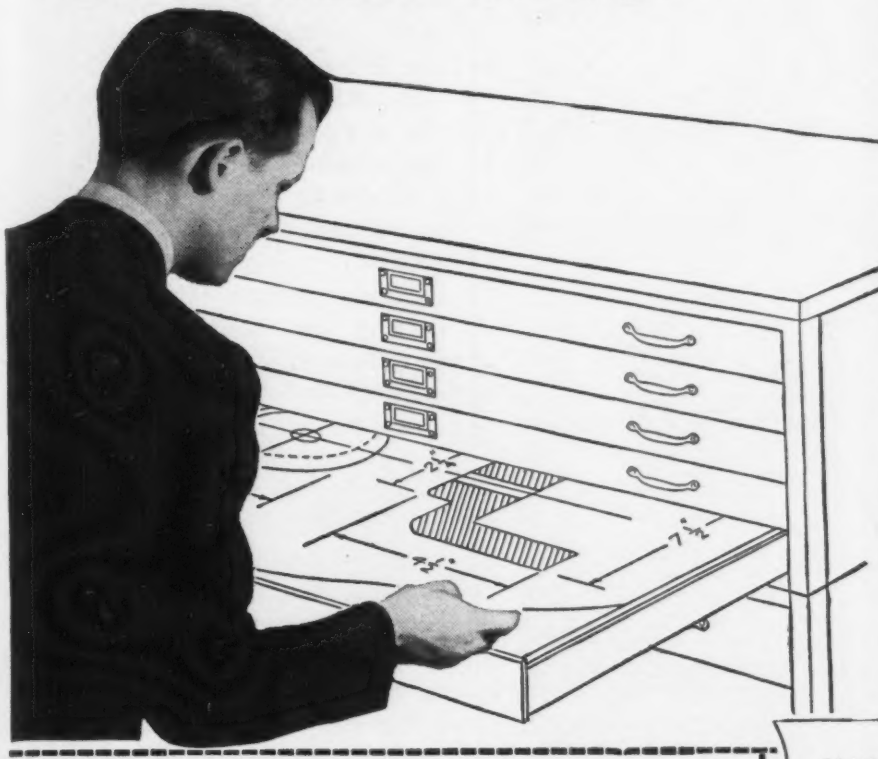

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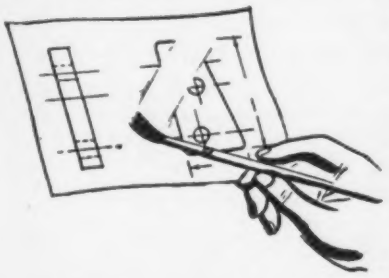

BW Transparents are mighty useful, too, when you want to make minor changes on a series of prints without altering the original tracing. Such changes can be made with ink or pencil on the BW Transparent, and the following BW Prints will bear these changes. To eliminate detail on the BW Transparent, use BW Eradicator. Another BW Eradicator is available for transforming the black lines to red lines on BW Prints to denote drawing changes.

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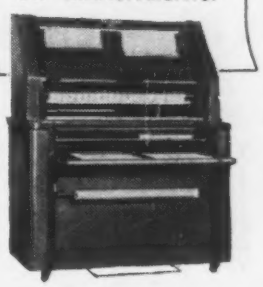

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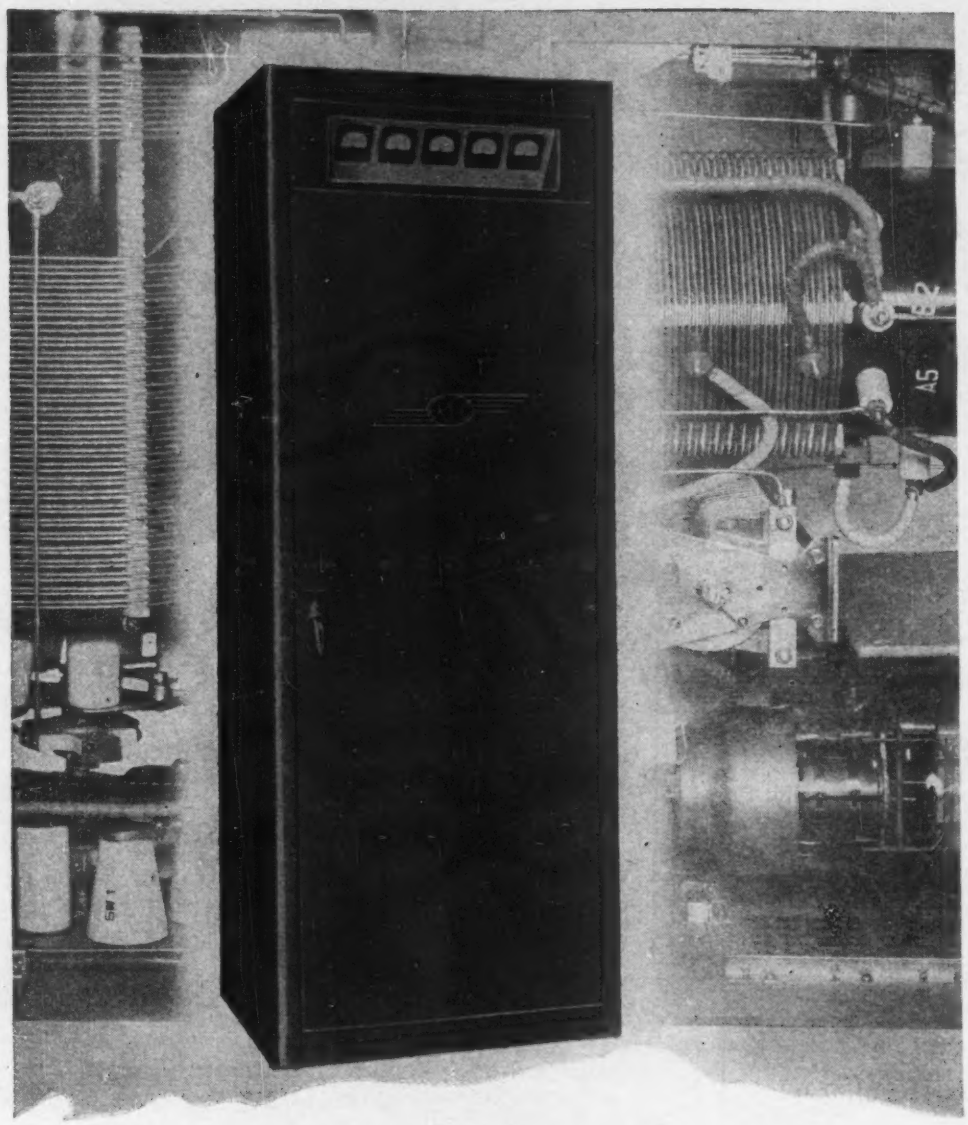

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160-T	*Specifications*	*170-T*
1000 watts	POWER OUTPUT	1000 watts
2 to 15 MC	FREQUENCY RANGE	200 to 500 KC
A1 and A3	EMISSION	A1 and A3
Local or remote	CONTROL	Local or remote

The 160-T COMMUNICATION Transmitter is designed for airways, coastal harbor, police or any point-to-point service where dependable telephone and telegraph communication is essential.

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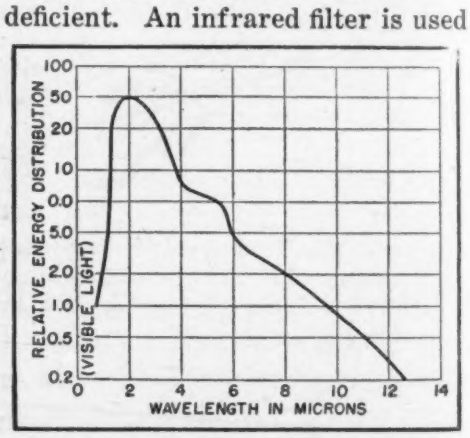
but as it is heated it becomes a progressively better conductor. To make the ceramic conductive, an exciting current—either direct or r-f—is applied to heat the radiator to 700 F. If the current is held constant the temperature will remain constant. It is necessary to use either a ballast resistor or a regulated current source to prevent the exciting current from increasing without limit.

Emission can be readily modulated by superimposing an audio-frequency current on the exciting current. Under some conditions the exciting current can be removed after the modulating current is applied. Because the emission of the glower varies as the fourth power of the absolute temperature, intensity modulation of the beam is pronounced. Because of conductive cooling to the surrounding air and the negative resistance characteristic, the emitter, despite its considerable mass, responds to voice frequencies.

The radiator can be small enough to constitute a point source, and thus be readily used with a spherical mirror to produce a beam, and still give appreciable radiation. The spectral response has its peaks where other infrared sources are deficient. An infrared filter is used



Spectral response of steatite shows a sharp peak just outside the visible region. Infrared radiation penetrates smoke and rain more effectively than visible light

to remove visible light from the beam.

Modulation of an Insulcon Glower, the emitter described above, is described in U. S. Patent No. 2,389,649, granted to Rawson E. Stark and Donald E. Stark, Stupakoff Ceramic & Mfg. Co. The German Army used a photophone for communication over short distances. A mechanical modulator controlled the amount of projected

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"Here's what the ELECTRONICS BUYERS' GUIDE does for me . . .

It gives me, in one book, the most complete and informative picture of components, 'packaged' equipment, and allied products that is available — information that I must have at my finger tips at all times. Previously, I have wasted considerable time searching for some individual company's literature in order to determine the characteristics of their product. Now it's just a matter of seconds to look up listings in the 'GUIDE' in order to get that information.

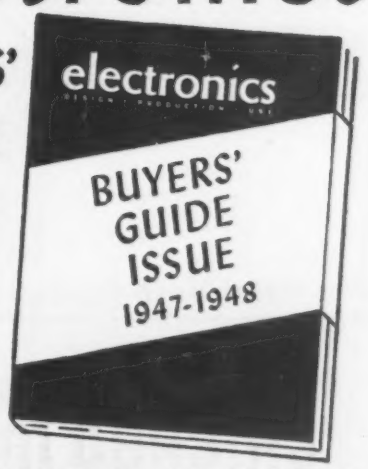
"Then, too, there are many times when I'm uncertain as to who makes a certain product, and here again the 'GUIDE' comes to my aid with a complete list of all available sources. No, I wouldn't want to get along without this 'reference book of the industry' — it's vitally important to me particularly when I design-in products and specify purchases."

Mr. Manufacturer . . .

This is not an isolated case—it's typical. Therefore, make sure your products are fully represented in the coming issue of the ELECTRONIC BUYERS' GUIDE which will be read and studied by the men who design, specify, create, and directly or indirectly influence purchases.

electronics BUYERS' GUIDE ISSUE

Coming JUNE 15 1947



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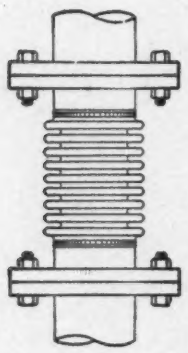
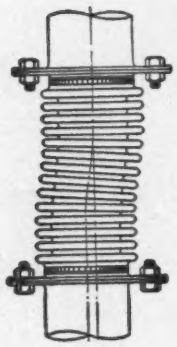
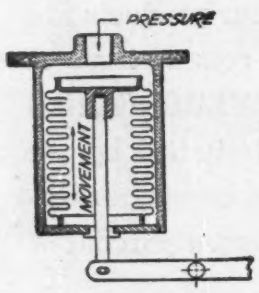


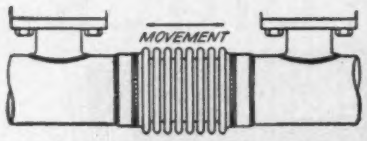
Expansion Joint



Flexible Connector



Pressure Motor



Compensator for Headers

C. M. H. STAINLESS STEEL BELLOWS

Assure

long life
low maintenance

The outstanding features of corrosion-resistant 18-8 Austenitic *Stainless Steel* enable wider application of C. M. H. Bellows. This is because *stainless steel* has the necessary characteristics to assure long life and low maintenance cost.

C. M. H. Bellows, for example, with a working range of sub-zero to a scaling-point of 1800° F. are not bothered by temperatures . . . hot or cold. In addition, they have multiple-ply construction for greater strength; ferrous fittings, attached by Circular Seam Welding to insure leakproof joints; uni-metal assemblies which avoid troubles often encountered when bi-metal or solder joints are used. These and other features warrant your consideration. Write for Bulletin SS B-46.

Flexible Metal Hose for Every Industrial Use

CHICAGO METAL HOSE CORPORATION
MAYWOOD, ILLINOIS
Plants: Maywood and Elgin, Ill.

radiation. A photocell received the beam. Vacuum tubes provided signal amplification, and a lens system focused the beam. The equipment and its operation are described in Dept. of Comm. reports PB-19746, 21 p; PB-1612, 14 p; PB-1623, 11 p; PB-2336, 22 p; and PB-1531, 54 p. Infrared sources bright enough to illuminate a road for 200 meters, used for driving in blackout, illuminating sniper targets, and identifying planes at night, are described in Dept. of Comm. report PB-1587. See also ELECTRONICS, Jan. 1944, p 156; June 1946, p 95 and 224.

Wideband I-F Amplifiers

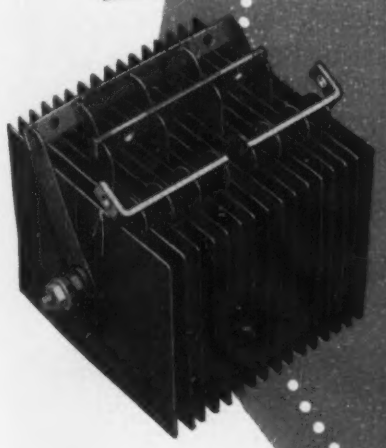
REQUIREMENTS of radiolocation i-f amplifiers are more stringent than for television amplifiers. Minimum background noise, rather than large gain or bandwidth, is the foremost requirement. A comparatively low i-f value gives low noise and makes use of conventional tubes but lacks wide band-pass and presents difficulties in separating the i-f carrier from the modulation in the detector. A higher i-f value gives better image frequency rejection and is less likely to amplify higher components of suppression pulses. Normally the i-f value lies between 10 and 60 mc.

Other things being equal, noise power is proportional to bandwidth. Important components of a rectangular pulse lie within a band $1/T$ cps wide, where T is the width of the pulse. Ideally the i-f amplifier bandwidth should be about $2/T$ cps wide. Optimum bandwidth is, however, best found by experiment. Investigations made to discover a particular shape of frequency-response curve for maximum signal-to-noise ratio show little preference. Single circuits, all in tune, are very inefficient couplings. Stagger-tuned circuits are easily set up and give high stage gain and an amplifier having broad bandwidth.

If the radiolocation i-f amplifier were left at full gain during transmission of pulses, the tubes would be overloaded. To overcome this damage, the amplifier is rendered

9 reasons why

SCA SELENIUM RECTIFIERS ARE RAPIDLY BECOMING STANDARD IN INDUSTRY FOR ALL RECTIFIER APPLICATIONS



1 Permanent characteristics.

2 Adaptability to all types of circuits and loads.

3 Unlimited life—no moving parts.

4 Immunity to atmospheric changes.

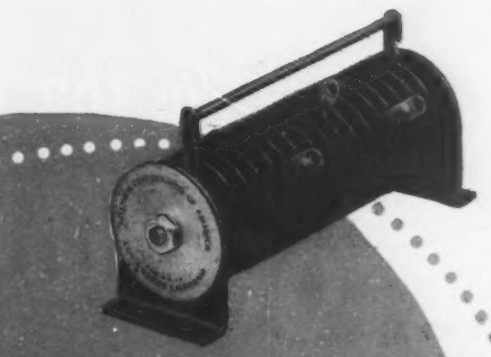
5 High efficiency per unit weight.

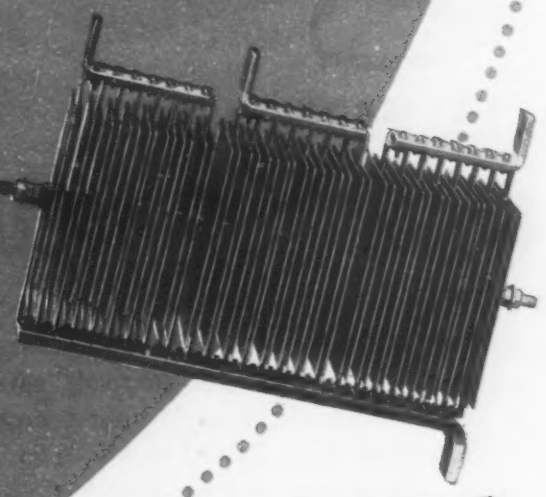
6 From 1 volt to 50,000 volts rms.

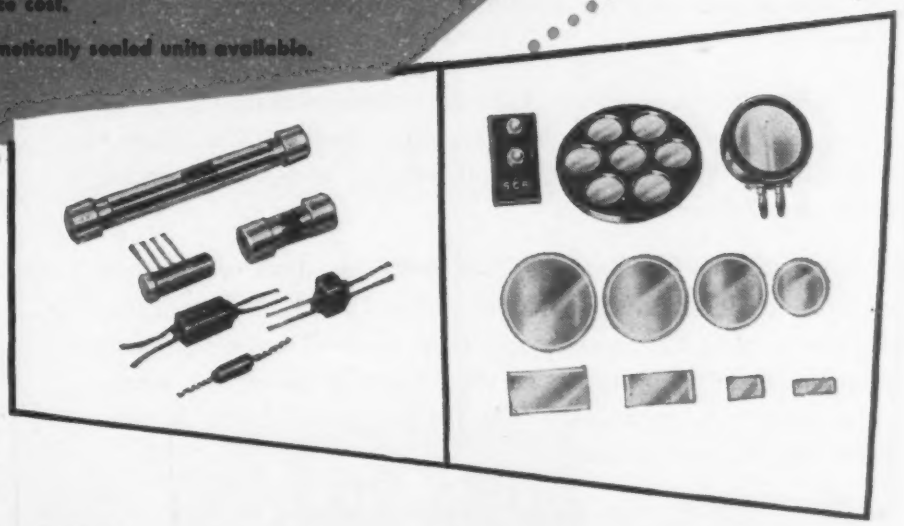
7 From 10 micro-amperes to 10,000 amperes.

8 Economical—simple to install—no maintenance cost.

9 Hermetically sealed units available.







The Modern Solution for all Rectifier applications. Selenium Rectifiers are ENGINEERED FOR ENGINEERS. Selenium Corporation of America meets exacting specifications of modern electronic developments. Manufacturers of a broad line of Selenium Power and Instrument Rectifiers, Self generating Photo-Electric cells and allied scientific products. Selenium Corporation of America's engineering experience can be called upon for the development and production of special rectifiers for any application.

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46-F

CML MODEL 1210

PORTABLE STROBOSCOPE

This newly developed stroboscope employs a novel circuit arrangement, using a self-blocking oscillator. Rotary or vibratory motion can be "stopped" when the moving object is examined with stroboscopic light source. The speed covered is from 600 to 48,000 RPM (10-800 CPS), in 4 ranges. A synchronized reed is provided for accurate calibration against the line frequency.

A valuable aid in industry for the slow-motion study of rotating, reciprocating, or vibratory mechanisms, CML 1210 is also useful for studying mechanical stresses and strains under dynamic conditions.

The light source is contained in a probe attached to a 4-foot flexible cable. This unusual feature makes CML 1210 especially useful when using the Stroboscopic light in small out-of-the-way places. The light probe and cable are housed in the cabinet when the Stroboscope is not in use. The handle of the probe is then used to carry the instrument.

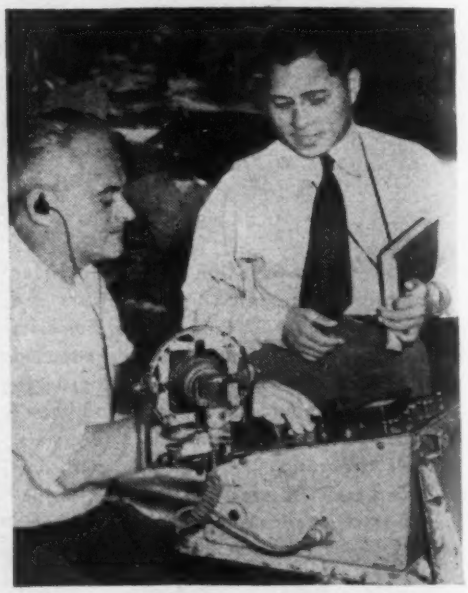
Write for Descriptive Bulletin

COMMUNICATION MEASUREMENTS LABORATORY
120 GREENWICH STREET, NEW YORK 6, N. Y.
Sales Offices: CHICAGO: 612 N. Michigan Ave—WASHINGTON: 924 19th St., N.W.
PHILADELPHIA: Van Dam Building, 10th and Market Sts.

inoperative by a large negative *suppression pulse,* usually applied to the screen grid of the first tube. The circuit must recover quickly after removal of the suppression pulse so that returns from nearby targets will be received. Because pulses from close targets will be of large amplitude, gain of the i-f amplifier may be raised slowly after removal of the suppression pulse by means of a saw-tooth wave. Such gain control is called *swept gain.* When it is more important to operate at the greatest gain consistent with background noise, avc is used.

Because the bandwidth of the i-f amplifier is very small compared to the transmitted carrier frequency, a discriminator circuit and automatic frequency control of the local heterodyne are used to hold the intermediate frequency in the center of the i-f band-pass despite frequency drift of the transmitter. Details of the discriminator are modified from those used in continuous-wave transmission to deal with pulse modulation. Further details of this investigation may be found in a paper by W. L. Watson, I. F. Amplifiers for Radiolocation Receivers, *South African Engr,* p 177, Aug. 1946.

Movie of a Movie



Chinese cinematographers, sent to Hollywood by the Chinese government to study American motion picture production practice, are making a documentary film for use in teaching motion picture technique to students at the Chinese University. John Cass is shown explaining to Chen Yang methods for mixing and monitoring voice signals at a portable console used on set

ALTEC LANSING

now offers

A UNIQUE LINE OF LOUDSPEAKERS UNEXCELLED IN ANY FIELD...FOR ANY USE

604 Duplex 15-inch

603 Multicell Dia-Cone 15-inch

600 Dia-Cone 12-inch

THE MODEL 604 DUPLEX fulfills professional requirements for a full 2-way speaker, reproducing the entire FM range without intermodulation or distortion. It provides the ultimate in sound quality . . . unsurpassed by any unit at any price.

THE MODEL 603 MULTICELL DIA-CONE meets the tremendous need for ultra high-fidelity sound that approaches the Duplex in quality, but is more economical in price. This speaker incorporates all the advantages of a 2-way multicellular speaker system.

THE MODEL 600 DIA-CONE is designed primarily for manufacturers catering to discriminating musical tastes. It is priced within the range of all connoisseurs who demand faithful reproduction of tone. They select this inexpensive unit as an auxiliary speaker for their receivers.

hearing is believing . . . ask your dealer for a demonstration

Cabinetry designed to enhance sound reproduction and harmonize with interiors is available for Models 604 and 603.

The Models 603 and 600 both employ the exclusive Dia-Cone construction principle, reproducing low frequencies and high frequencies from separate diaphragms.

"KEEP ADVANCING WITH ALTEC LANSING"

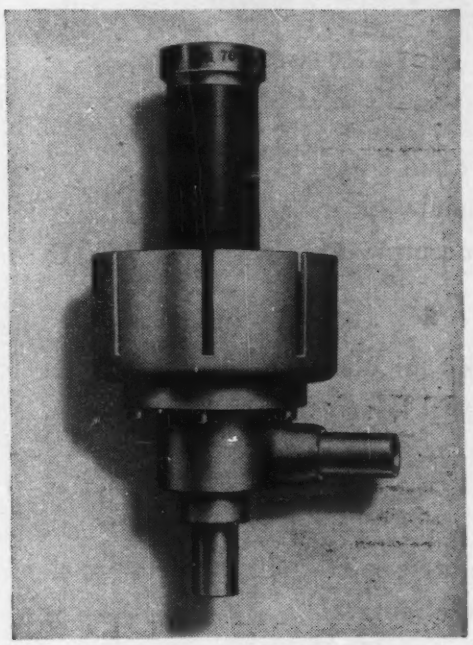
NEW PRODUCTS

Edited by A. A. McKENZIE

New apparatus, component parts, packaged units and allied equipment are described. Catalogs and manufacturers' publications are reviewed

Water-Cooled Resistor

INTERNATIONAL RESISTANCE CO., 401 North Broad St., Philadelphia, Pa. A new development is the type LP liquid cooled, high-frequency, high-power resistor designed particularly for television, f-m, and dielectric heating applications. The resistance film is thin and has an

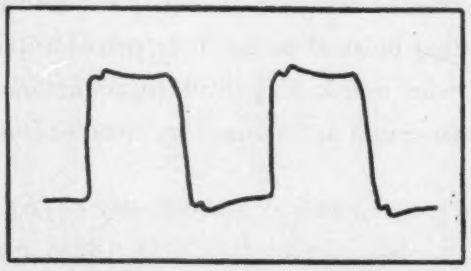


active length considerably less than a quarter wavelength at f-m frequencies. A high-velocity stream of water flows against the film to cool it. Power dissipation up to 5 kilowatts is permissible. The resistor is available in values between 35 and 1,500 ohms. Standard tolerance is plus or minus 15 percent.

and industrial heating applications. The tube is water-cooled, but is fitted for quick insertion in the electrical circuit and connection to water lines.

Music Amplifiers

BROOK ELECTRONICS, INC., 34 De Hart Place, Elizabeth, N. J. The Brook amplifiers, models 10C, 10C2 and 10C5 comprise the same basic unit, a square-wave response curve



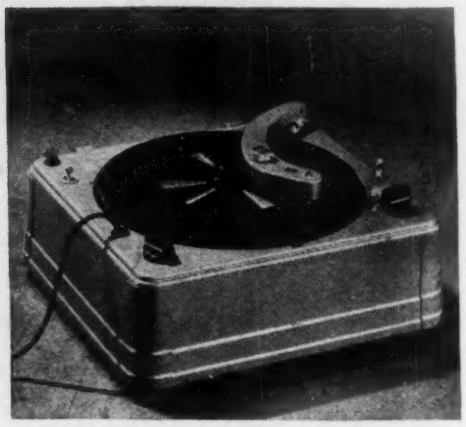
Response of the model 10C amplifier to a 5,000 cycle square wave

of which is illustrated, but differ in the amount of supplementary control equipment. All units are built on a 17-inch chassis suitable for rack mounting. Audio transformers of special design are used throughout, and the output transformer will not saturate with 34 watts output at 25 cycles. Response of the amplifiers is flat within 0.2 db from 15 to 25,000 cycles.

The Model 30A preamplifier and mixer is powered by either the 10C amplifier to which it is attached or from a separate supply. It can be mounted adjacent to or at a distance from the output amplifier depending upon requirements.

Talking Letters

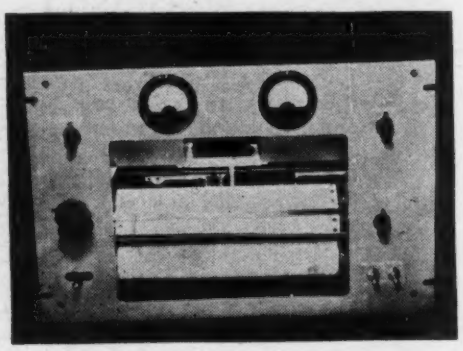
THE BRUSH DEVELOPMENT CO., 3405 Perkins Ave., Cleveland 14, Ohio. The Mail-A-Voice recorder-reproducer uses paper recording blanks coated with a magnetic material. When records are made or played back a grooved spiral plate, concentric with the paper record, is



placed upon the turntable to serve as a guide for the magnetic tone arm. Since there are no grooves in the records themselves, they can be folded without damage, the voice erased with a small magnet, and the records reused a great number of times.

Twin Recorder

SOUND APPARATUS CO., 233 Broadway, New York 7, N. Y. A newly developed dual recorder can be used

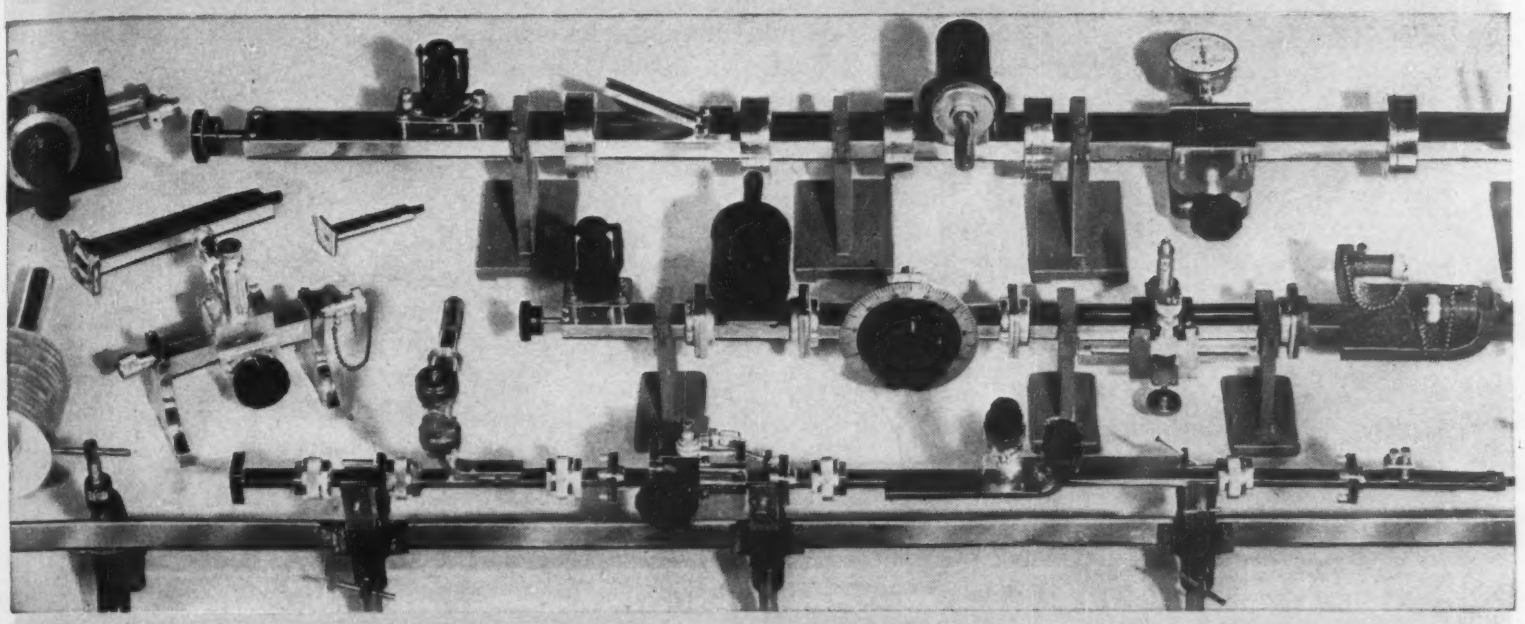


C-W Magnetron

GENERAL ELECTRIC CO., Syracuse, N. Y. A new magnetron furnishing 5 kilowatts of continuous-wave power at 1,050 megacycles is expected to prove useful in plastics

DE MORNAY · BUDD
STANDARD TEST EQUIPMENT

For Precision Measurements in the Microwave Field



The complete line of De Mornay·Budd standard test equipment covers the frequency range from 4,000 mcs. to 27,000 mcs. It provides all R. F. waveguide units necessary for delicate, precision test work requiring extremely high accuracy in attenuation measurements, impedance measurements, impedance matching, calibration of directional couplers, VSWR frequency measurements, etc.

To eliminate guesswork, each item of this De Mornay·Budd test equipment is individually tested and, where necessary, calibrated, and each piece is tagged with its electrical characteristics. All test equipment is supplied with inner and outer surfaces gold plated unless otherwise specified.

NOTE: Write for complete catalog of De Mornay·Budd Standard Components and Standard Bench Test Equipment. Be sure to have a copy in your reference files. Write for it today.

The three test set-ups illustrated above include:

Tube Mount
Flap Attenuator
Frequency Meter
Calibrated Attenuator
Tee
Stub Tuner
Tunable Dummy Load
Standing Wave Detector
Type "N" Standing Wave Detector
Directional Coupler
Hight Power Dummy Load
Cut-Off Attenuator

Stands, etc.

DE MORNAY BUDD

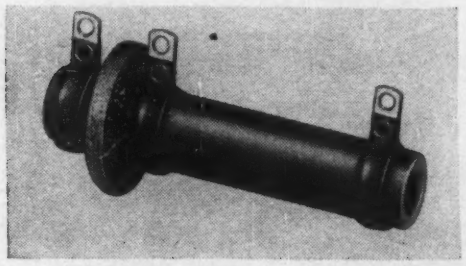
EQUIPMENT FOR 97% OF ALL RADAR SETS

DE MORNAY • BUDD INC., 475 GRAND CONCOURSE, NEW YORK 51, NEW YORK. CABLE ADDRESS "DEMBUD," N. Y.

for the simultaneous observation of two different phenomena, such as noise and vibration, or average and rms values. Built in rack form, measuring 12¼ by 19 inches, the unit has two synchronous motors, one for the writing pens and one for moving the chart.

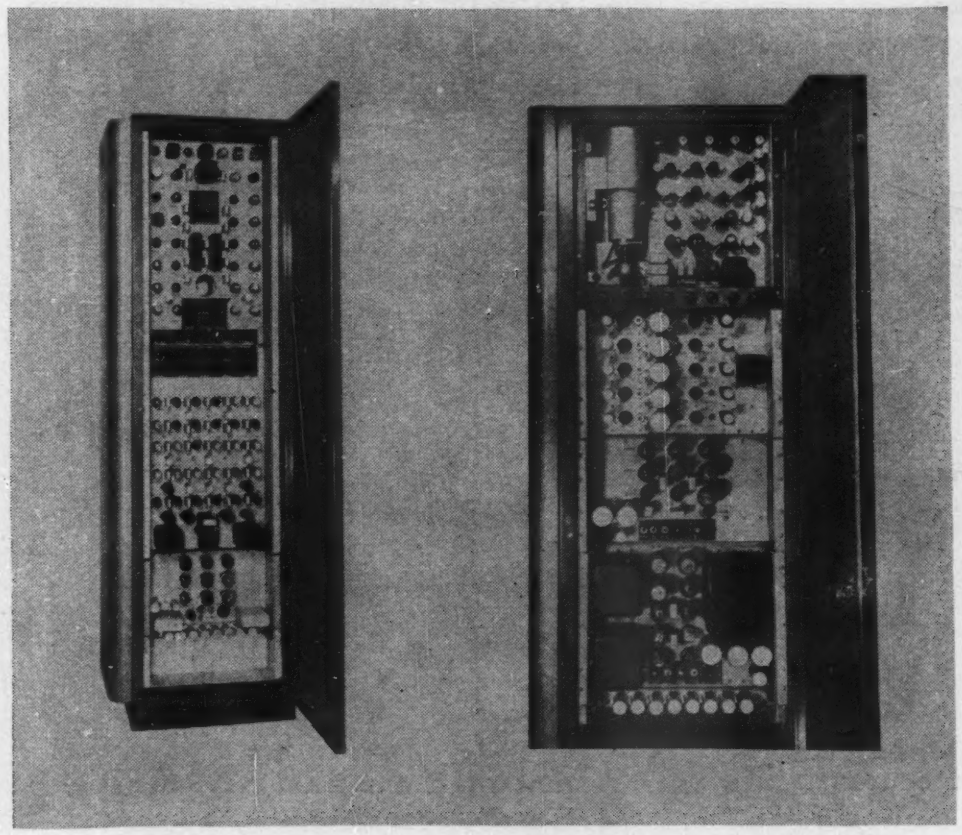
Video Network

P. R. MALLORY & Co., Indianapolis, Ind. The Videocoupler is a three-terminal network designed to couple the video amplifier to the picture tube in television receivers. The unit comprises two peaking inductors and a load resistor.



Television Test Units

RADIO CORP. OF AMERICA, Camden, N. J. Television test units illustrated here for broadcast stations and production lines comprise the type TG-1A synchronizing generator at the left, as well as the type TK-1A monoscope camera, and type TA-1A distribution amplifier shown at the right. The synchronization generator produces five fundamental timing and synchronizing impulses necessary for RMA standard 525-line, 30-frame interlaced scanning systems. The monoscope provides a fixed standard video signal, while the amplifier serves to mix the signal impulses or send them out through separate lines with complete isolation of input and output circuits.

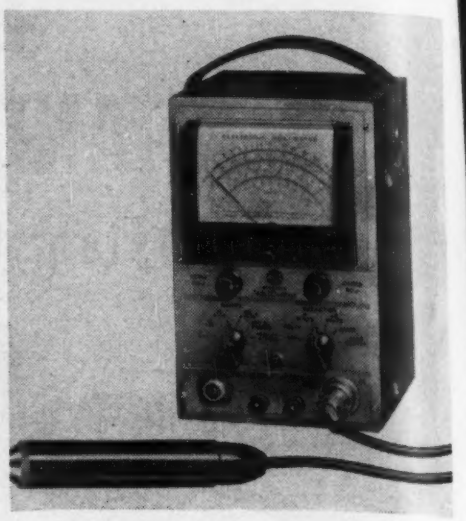


Microphone Stand

SNYDER MFG. CO., 22nd and Ontario Sts. Philadelphia 40, Pa. The new microphone stand features a heavy cast-iron base and quick-grip locking nut to hold the stand at any position from 30 to 60 inches high. List price is $7.75.

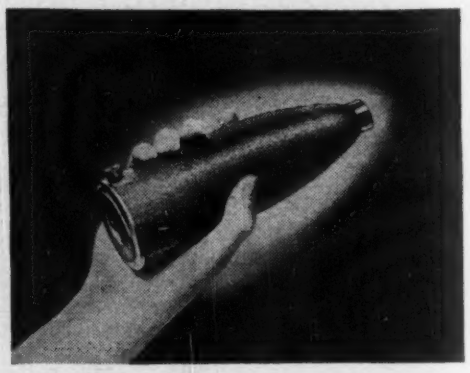
New Voltohmyst

RADIO CORP. OF AMERICA, Camden, N. J. Using a newly developed diode probe, the type WV-75A meter can be employed for high-impedance circuit testing at frequencies up to 250 megacycles. Radio receiver voltages up to 1,000 volts can be measured directly on either a-c or d-c. Bias cell, afc, and avc voltages can be checked. Six resistance scales allow measurements up to 1,000 megohms. The meter weighs only 9 pounds.



Condenser Microphone

WESTERN ELECTRIC CO., INC., 195 Broadway, New York 7, N. Y. The type 640AA studio microphone was originally developed and used for laboratory and field work in sound studies. Recently this microphone has been used with great success in high-fidelity broadcasting. A feature of the microphone contributing to its excellent response is the fact that the diaphragm is flush with the end of the microphone, avoiding cavity resonance effects. The microphone serves to cover a large area and can be suspended so as to give essentially nondirectional pickup.



Wired Music Amplifier

ALTEC LANSING CORP., 250 West 57th St., New York 19, N. Y. A new high-quality, low-price ampli-

PERMANENT MAGNETS MAY DO IT BETTER!

Now! we're ready to Demonstrate HYFLUX*

Magnetic Recording Tape with *full fidelity* performance

HYFLUX magnetic recording tape is a new "packaged energy" product of The Indiana Steel Products Company offering for the first time full, rich, high fidelity performance at moderate operational speeds. HYFLUX, the result of over a third of a century of experience in permanent magnet production augmented by independent research of the Battelle Memorial Research Institute, is a paper tape coated with fine high-energy magnetic particles with characteristics comparable to the well-known grades of Alnico. The simplicity of its design, its high fidelity performance, and the low cost materials used in fabrication provide HYFLUX tape with exceptional advantages for modern commercial recording.

Although The Indiana Steel Products Company will only produce HYFLUX Tape itself, the importance of developing a soundly engineered recorder for HYFLUX magnetic tape was recognized. The combined work of The Indiana Steel Products Company and the Physics Research Division of the Midwest Research Institute resulted in a single basic mechanism which incorporates outstanding new refinements in recording magnetics, electronics, mechanics, and acoustics. These engineering findings will be available to all recording machine manufacturers who are HYFLUX licensees. *Write today for additional information on the technical application of* HYFLUX *recording tape.*

* Reg. U. S. Pat. Off.

HYFLUX Magnetic Recording Tape Brings These New Advantages to the Field of Sound Recording

- High Fidelity Performance
- Low Operating Cost
- Compact . . . ½ hour recording on a single 8 MM reel.
- Flexible and Durable in Use
- Permits Precision Editing

★ THE INDIANA STEEL PRODUCTS COMPANY ★

PRODUCERS OF "PACKAGED ENERGY"

6 NORTH MICHIGAN AVENUE • CHICAGO 2, ILL.

SPECIALISTS IN PERMANENT MAGNETS SINCE 1910

PLANTS { VALPARAISO, INDIANA
STAMFORD, CONN. (CINAUDAGRAPH DIV.)

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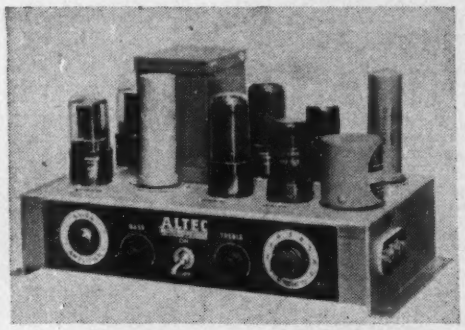
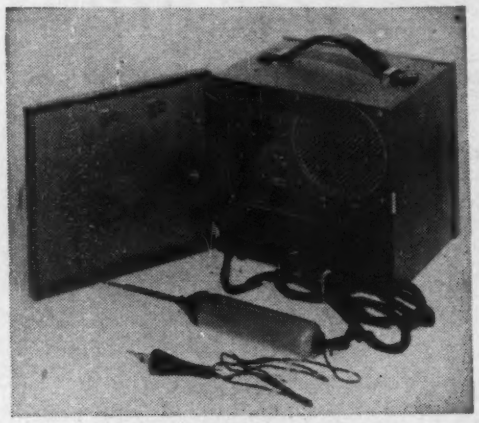
fier, type A-319, has been designed for home phonograph or commercial wired music systems. Bass and treble boost are provided, but



the amplifier is essentially flat from 40 to 15,000 cycles without use of these controls. The power output is 4 watts and the equipment can be operated on either a-c or d-c lines. There are two models, A and B, that differ in weight and line input impedance.

Signal Tracer

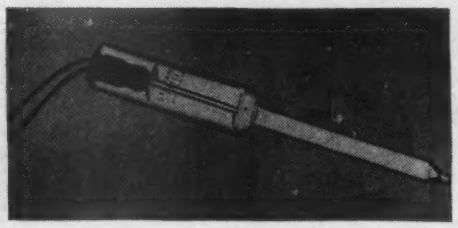
SPECIAL PRODUCTS CO., Silver Springs, Maryland. A battery-operated portable signal tracer weighing less than 5 pounds includes a



long probe to reach inaccessible points in a receiver, a gain control, and a loudspeaker. A jack is provided for an output meter.

Pirani Tubes

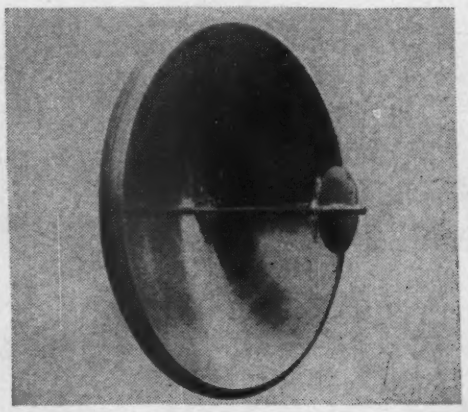
SYLVANIA ELECTRIC PRODUCTS, INC., 500 Fifth Ave., New York 18, N. Y. Pirani tubes with tungsten filaments operating at 1.5 volts, 100 milliamperes, are available in matched pairs for use with a 0-1 milliampere meter in a simple bridge circuit. The type R-1111 tubes so used give readings accur-



ate to plus or minus 5 percent within a pressure range of one to 1,000 microns. Nonex envelopes with tubulation are provided.

Relay Antenna

THE WORKSHOP ASSOCIATES, INC., 66 Needham St., Newton Highlands 61, Mass. Antennas for use in the 920 to 960 megacycles and 1,295 to 1,375 megacycle relay bands are now in production. The dish-type



antennas have a power gain of 50 with half-power angles of 21.5 degrees in the vertical and 18.5 degrees in the horizontal plane. Standing wave ratio is less than 1.5 to 1 when the antenna is connected to a 52-ohm line.

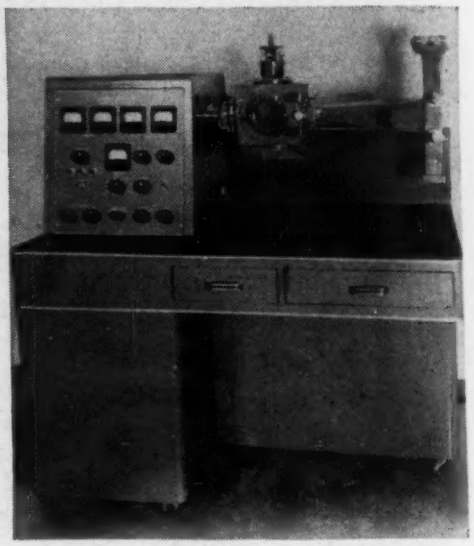
Modulation Meter

SYLVANIA ELECTRIC PRODUCTS, INC., 500 Fifth Ave., New York 18, N. Y. The type X7018 modulation meter

will be useful to radio amateurs, as well as police and marine stations in the frequency range 1.8 to 54 megacycles. When properly installed near an a-m transmitter it will indicate percentage of modulation and any carrier shift. A headphone jack is also provided for aural check of modulation distortion and hum. The equipment is relatively simple in construction and requires no batteries or external power connection by virtue of using two crystal diodes.

Electron Diffraction

GENERAL ELECTRIC CO., Syracuse, N. Y. Fifteen electron diffraction instruments are now being manufactured for the study of quartz crystals and metal surfaces. Specimens weighing up to 40 pounds are



bombarded, under vacuum, with electrons that bounce off to be photographed in the form of a diffraction pattern on a plate. The equipment is useful in a submicroscopic study of surfaces and in determining the photoelectric work function of various alloys.

Flash Tube

SYLVANIA ELECTRIC PRODUCTS INC., 500 Fifth Ave., New York 18, N. Y. The new type R-4340 flash tube provides a peak output of 48 million lumens or four times that of the type R-4330. Uniformity of the illumination between 4,000 and 7,000 angstroms makes the new tube

"Q. C." keeps white elephants off your presses

One of the kingpins in Armco's production of Quality-Controlled Electrical Steels is the mill representative. In a sense he works for *you,* not us.

This roving ambassador of "Q.C." who visits your plant has only one objective: to see that you get the *one right electrical steel* for your products. He wants no "white elephants" holding up your presses or clogging production lines.

"Q.C." — Quality Control — is no stranger to Armco mill representatives and production supervisors. Control charts and statistical analysis are developments of recent years; they help assure consistent production of prime Armco sheets.

But control charts are only part of the story. For almost 20 years "Q.C." has been a live, familiar term in the Armco mills. It governs the control of sheet steels even before the "charge" goes into the open-hearth furnace.

INDIVIDUAL ROUTINGS

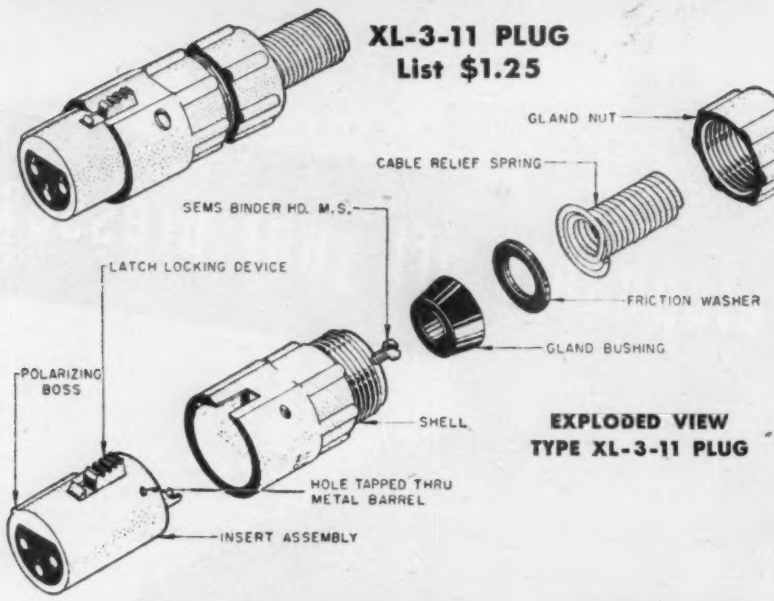
The salesman, mill representatives and metallurgists study your order and its requirements—determine for what purpose the steel will be used and how it will be fabricated. Then, on your individual routing card, metallurgists specify the mill routing that will give your electrical steels the properties they need.

In all these deliberations the Armco mill representative first keeps *your* problems in mind. He is your assurance of a high "Q. C." in the ARMCO Electrical Steels that go into your products. The American Rolling Mill Company, 4731 Curtis Street, Middletown, Ohio.

ELECTRICAL ★ ARMCO ★ SHEET STEELS

THE AMERICAN ROLLING MILL COMPANY

Special-Purpose Sheet Steels • Stainless Steel Sheets, Bars and Wire



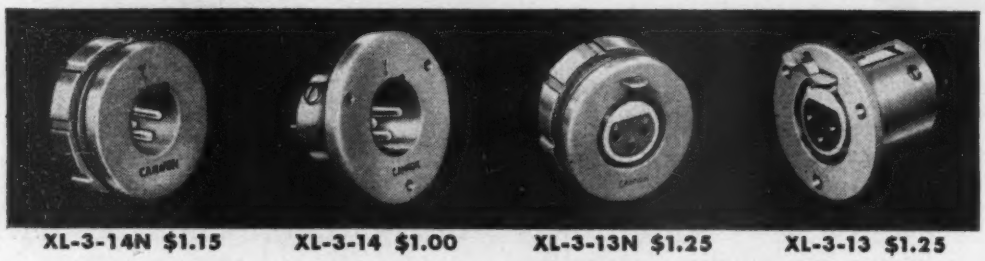
XL PLUG CONSTRUCTION MEANS LONG LIFE

RCA Announce Mike, Cannon Electric Equipped

YEARS OF EXPERIENCE and success building multi-contact electric connectors have gone into the design and manufacture of this new line of "XL" fittings for low-level sound transmission circuits and other general electrical uses.

A good plug can be taken apart for wiring and inspection and put back together again. You'll find this easily done with the "XL," because of its superior engineered features. Note the above exploded view. From the high quality, molded insert insulation with silver-plated brass contacts, through the diecast zinc shells, with bright nickel finish, the patented latchlock device, gland bushing, friction washer and cable relief spring—you get A-1 construction features in a connector in the moderate price class.

XL RECEPTACLES FOR VARIOUS TYPES OF MOUNTING

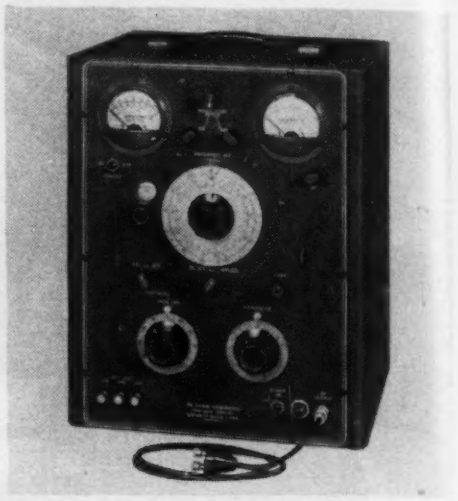


XL-3-14N $1.15 XL-3-14 $1.00 XL-3-13N $1.25 XL-3-13 $1.25

AMPERAGE AND VOLTAGE: The three contacts have 15-amp. capacity with a minimum flashover voltage of 1500 volts (250 volts working voltage).

Write for the new Bulletin "XL-246," describing the fittings illustrated above and also the three "XL" adapters for popular makes of microphones. Address Dept. L-120, Cannon Electric Development Co., Los Angeles 31, Calif. Write Cannon Electric Co., Ltd., Toronto for Canada and British Empire; Frazar & Hansen, 301 Clay St., San Francisco 11, Calif. for other world trading areas.

CANNON ELECTRIC
DEVELOPMENT COMPANY
3209 Humboldt Street, Los Angeles 31, California
Canada & British Empire — Cannon Electric Co., Ltd., Toronto, Ontario • World Export Agents (excepting British Empire) Frazar & Hansen, 301 Clay St., San Francisco 11, Calif.



tion ranges, 0 to 80, and 0 to 240 kilocycles. The instrument is also available for amplitude modulation tests with 30 and 50 percent modulation. A monitoring meter standardizes the output level. Output impedance is 26.5 ohms. Power supply is self-contained and operates from ordinary socket power.

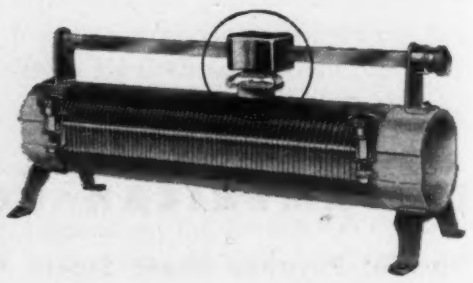
Auto Radio Vibrators

NATIONAL UNION RADIO CORP., Newark, N. J. Replacements for over 2,500 different models of auto

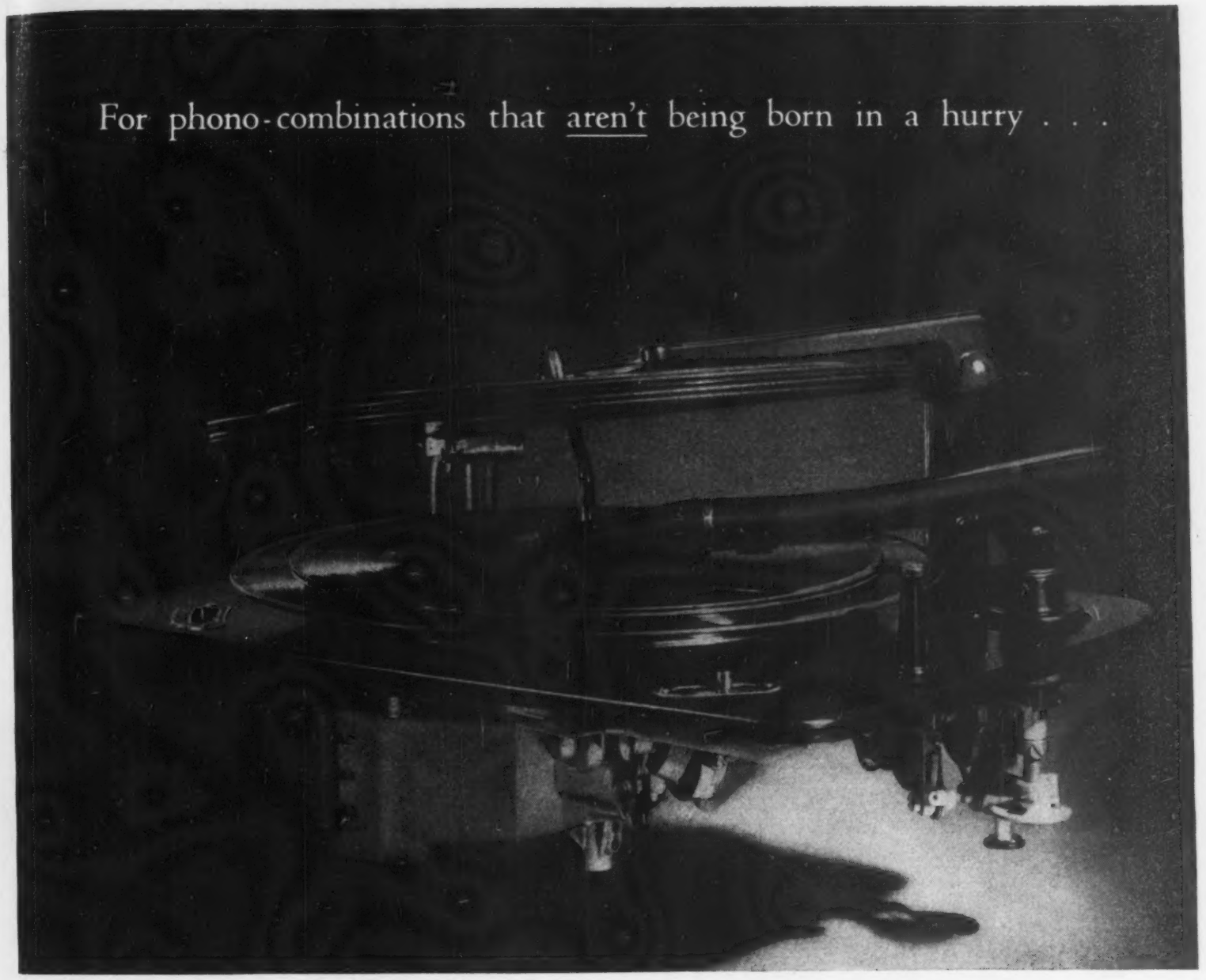
radio vibrators have been standardized to a minimum of 8 types now being manufactured under the brand name Univibes.

Tubular Rheostat

REX RHEOSTAT CO., 3 Foxhurst Road, Baldwin, L. I., N. Y. A new tubular slide-contact rheostat, type



For phono-combinations that aren't being born in a hurry . . .



If you manufacture the kind of combination that takes its precious time coming off the drawing board – and off the assembly line – Garrard is your record changer.

For the most part, Garrard changers have been finding their way into those custom-built assemblies where every component is hand-picked, without a sidewise glance at cost. Your finest combinations are made that way, and there is every reason why you can and should select Garrard.

It's as simple as this: with Garrard in your combination, you can feature the changer as you feature cabinetry and tone quality. You can point up the watch-like construction; the exclusive governor-controlled, speed-regulated motor; the non-slip spindle . . . and more. Most important . . . Garrard has the "look" of belonging in distinctive sets.

Send for a sample changer. Garrard Sales Corporation, 315 Broadway, New York 7, New York.

PRECISE AS A WATCH

1. Exclusive speed-regulated, governor-controlled motor
2. Completely automatic intermixing
3. True tangent, jewelled-pivot tone arm
4. Exclusive non-slip spindle
5. Automatic stop
6. Heavy fly-wheel action built into turntable
7. Only one operating control required
8. Full swivel tone arm for changing needles
9. Kind to fragile records; no knives or trick spindles

. . . they ask for it by name . . .

GARRARD

WORLD'S FINEST AUTOMATIC RECORD CHANGER

GARRARD ADS APPEAR CONTINUALLY IN EVERY IMPORTANT CONCERT PROGRAM AND IN LEADING HOME-FURNISHINGS PUBLICATIONS

insuline
MAKERS OF THOUSANDS OF RADIO AND ELECTRONIC PARTS
COMPLETE FACILITIES FOR FILLING YOUR "to specification" ORDERS
TREMENDOUS STOCKS OF QUALITY STANDARD PARTS

Insuline began to design, develop and produce quality radio parts for the industry a quarter of a century ago.

Today, Insuline produces one of the biggest lines of standard parts — everything from a small stamping to a giant transmitter cabinet—and occupies an enviable position as a to-your-specifications manufacturer.

You'll find quantity and quality, speed and precision, at Insuline. You'll find more complete details in Insuline's hot-off-the-press catalog. Write Dept. E-3 for your copy—now!

insuline
Corporation of America
INSULINE BUILDING · LONG ISLAND CITY, N. Y.
More than a quarter-century of Quality production

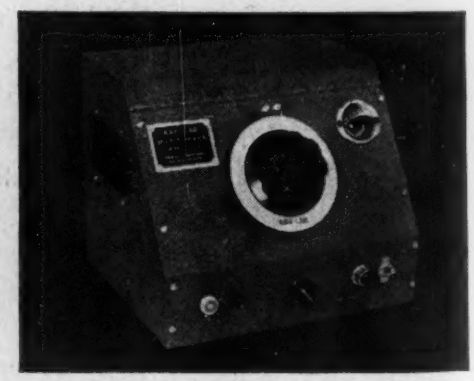
E, features a pair of copper-graphite contact blocks, connected by a leaf spring of phosphor bronze. One block bears against the resistance winding and the other against the slider bar so that the contact is lubricated and arcing prevented. There are 16 ohmic values in which the resistor is regularly manufactured. Power rating of any unit is 450 watts. Other types of units manufactured by the company are described in Catalog No. 3.

Individual Receiver

EMERSON RADIO AND PHONOGRAPH CORP., 111 Eighth Ave., New York 11, N. Y. A broadcast receiver equipped with an output for a hearing aid receiver on a separate volume control, in addition to the regular loudspeaker and its control, has been announced. The table-model receiver will retail for $45.

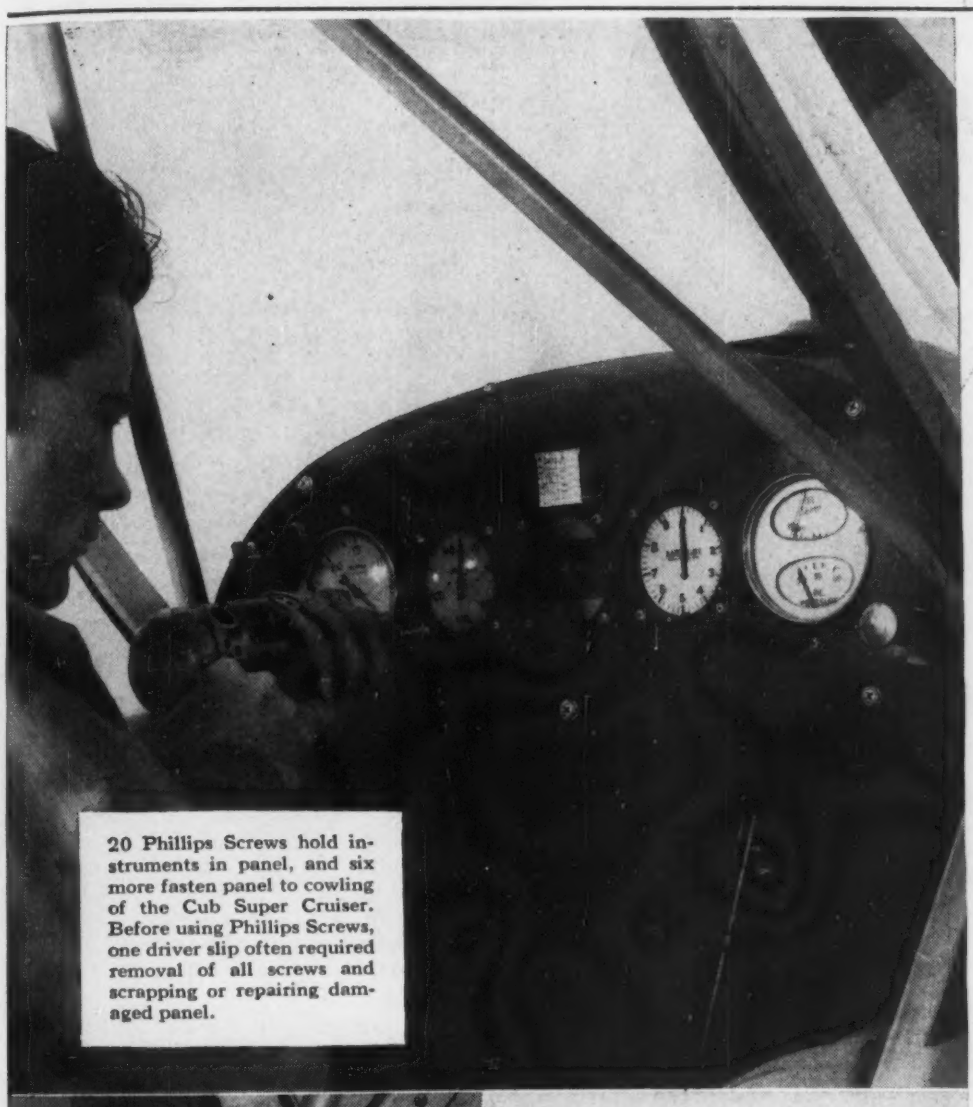
Shunt Capacitance Meter

KALBFELL LABORATORIES, 1076 Morena Blvd., San Diego 10, Calif. The model 401A Micro-Miker has been particularly designed to meas-



"DRIVE TWICE AS FAST"

—Phillips Screws help Piper build 1100 Cubs a month!



20 Phillips Screws hold instruments in panel, and six more fasten panel to cowling of the Cub Super Cruiser. Before using Phillips Screws, one driver slip often required removal of all screws and scrapping or repairing damaged panel.

Fastenings near fabric covering—no place for driver slips—no slips with Phillips Screws.

The 20,000th Piper Cub, completed June 1946. Phillips Screws speeded this big production!

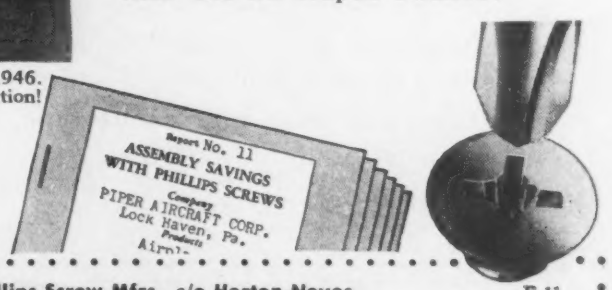
"We started using Phillips Screws back in 1938, when . . . and because . . . we were getting set for large scale production," declared Piper's Assistant Chief Inspector to the James O. Peck Co. investigator, studying assembly savings with Phillips Screws in well-known plants. "Today we're shipping our 20,000th Piper Cub. That proves how much faster Phillips Screws are to drive.

"IDEALLY SUITED TO POWER DRIVING, which we needed for high production. Unlike slotted screws, Phillips Screws hold the driver bit in place without a guide or other support, automatically center themselves in the screw holes and catch the thread quicker. Phillips Screws are easily twice as fast to drive.

"TAKES LESS TIME TO MAKE SKILLED ASSEMBLERS. It takes a man much less time to become familiar with and do a good job of driving Phillips Screws. Since the Cub is fabric covered, any driver slips would cost us expensive, undesirable patching, doping and repainting . . . up to $1.00 a slip. Same thing on the instrument panel where a single driver slip would cost up to $3.50. If we were using slotted screws, assemblers would have to go much slower, especially at the learning stage, to avoid such damage.

"WE GET A BETTER INSPECTION. Don't have to watch out for burred heads as we used to do with slotted screws. Fabric tears and instrument panel scratches are out. And the Phillips Recessed Head certainly makes a more attractive, workmanlike job wherever screw heads are exposed."

GOOD IDEAS FOR YOUR ASSEMBLY LINE in this independently made report of Piper's assembly savings with Phillips Screws. Similar studies . . . covering metal, wood and plastic products . . . available to you without cost or obligation. Use the coupon TODAY!



PHILLIPS *Recessed Head* SCREWS

Wood Screws • Machine Screws • Self-tapping Screws • Stove Bolts

26 SOURCES

American Screw Co.
Atlantic Screw Works
Atlas Bolt & Screw Co.
Central Screw Co.
Chandler Products Corp.
Continental Screw Co.
Corbin Screw Div. of American Hdwe. Corp.
The H. M. Harper Co.
International Screw Co.
Lamson & Sessions Co.
Milford Rivet and Machine Co.
National Lock Co.
National Screw & Mfg. Co.
New England Screw Co.
Parker-Kalon Corporation
Pawtucket Screw Co.
Pheoll Manufacturing Co.
Reading Screw Co.
Russell Burdsall & Ward Bolt & Nut Co.
Scovill Manufacturing Co.
Shakeproof Inc.
The Southington Hardware Mfg. Co.
The Steel Company of Canada, Ltd.
Sterling Bolt Co.
Stronghold Screw Products, Inc.
Wolverine Bolt Company

Phillips Screw Mfrs., c/o Horton-Noyes E-11
2300 Industrial Trust Bldg., Providence, R. I.

Send me reports on Assembly Savings with Phillips Screws.

Name.....

Company.....

Address.....

.....

To make Micro-Waves behave ..."Moldlock" Flexible Wave Guides

"MOLDLOCK," one of the three basic types of American Flexible Wave Guides, consists of a full, four-wall interlocked tubing made from silver laminated bronze or tinned bronze strip, with precision bronze flanges and covered with a molded synthetic jacket.

"Moldlock" is designed for mechanical installations where considerable misalignment must be compensated for, or where vibration or difficult bends and twists are problems.

The "Moldlock" type, the Vertebra type, and the newer Seamless Wave Guide mate electrically and mechanically with common sizes of rigid guide, and provide for operation at wave lengths from 20 to 1¼ Cm. We will gladly aid in selecting the most appropriate type, based on specific requirements of the installation.

Further information on request. 46358

ANACONDA *American Metal Hose*

THE AMERICAN BRASS COMPANY · AMERICAN METAL HOSE BRANCH

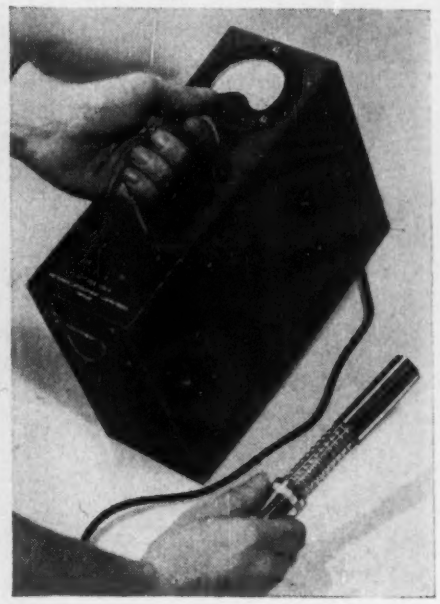
General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company

ure small capacitances in amplifiers, including stray capacitances between wiring and chassis. The measurement is made by direct substitution in a parallel resonant circuit at a frequency between 2.5 and 3.5 megacycles. Range of the equipment is 1 to 230 micromicrofarads.

Radioactivity Probe

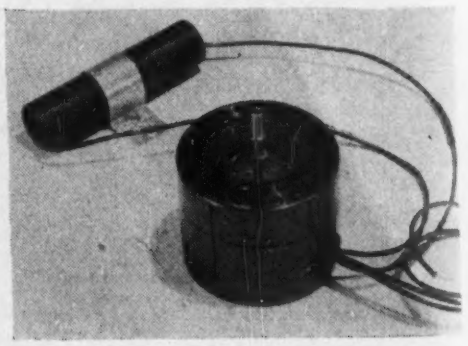
INSTRUMENT DEVELOPMENT LABORATORIES, 817 E. 55th St., Chicago 15, Ill. A portable beta-gamma count rate meter has been developed for locating radioactive material. The model 2610 meter has



three ranges, up to 20 milliroentgens per hour full scale. A detachable four-foot cable allows probing with the Geiger tube. A headset is furnished for rapid surveying. Self-contained batteries will operate the equipment for 500 four-hour-daily periods.

Small Motor

FAIRCHILD CAMERA AND INSTRUMENT CORP., 88-06 Van Wyck Blvd., Jamaica 1, N. Y. A new 117-volt,



NOW...

SPRAGUE brings you a 2 MIL. METER MULTIPLIER that gives you a...

50% REDUCTION IN RESISTANCE VALUE!

Conventional multipliers wound with ordinary enamelled wire cannot operate safely at much more than the one MA called for in government specifications. Sprague Precision Meter Multipliers, however, can be used at *twice their normal current rating,* with only a slight decrease in long time stability. Plus or minus 1% resistance tolerance should be specified.

This cutting of resistance value in *half,* with approximate halving in meter multiplier cost, results from use of wire that is insulated before winding, with a 1000° C. heat-proof ceramic and wound on special high-temperature plastic forms. *Larger wire sizes* are used through reduction of resistance values.

It all adds up to a net saving of as much as 50% in multiplier cost . . . because it allows exactly half the resistance value and, in some cases, half the number of multipliers, to be used for a given application. Sprague engineers will be glad to make recommendations for your specific application.

Write for the new Sprague Resistor Catalog No. 100E.

SPRAGUE ELECTRIC COMPANY, Resistor Division, North Adams, Mass.

SPRAGUE *KOOLOHMS

POWER TYPES • BOBBIN TYPES • METER MULTIPLIERS • MEGOMAX, ETC.

*Reg. U. S. Pat. Off.

for PRECISION TESTING

Standardizing the "POP" in Toasters 24 Hours a Day *Without Burning a Slice...*

SORENSEN Regulators straighten out weaving input voltages. It's done the electronic way... without moving a muscle. No moving parts assure you of quick response, low maintenance and longer life.

Protecting costly laboratory apparatus from overvoltages, speeding up assembly line testing or applied to any of your regulation problems, the SORENSEN Regulator can be counted on to do the job with precision and accuracy.

Write for more information.

Arrange for a demonstration today.

A LINE OF STANDARD REGULATORS FOR LOAD RANGES UP TO 30 KVA
SPECIAL UNITS DESIGNED TO FIT YOUR UNUSUAL APPLICATIONS.

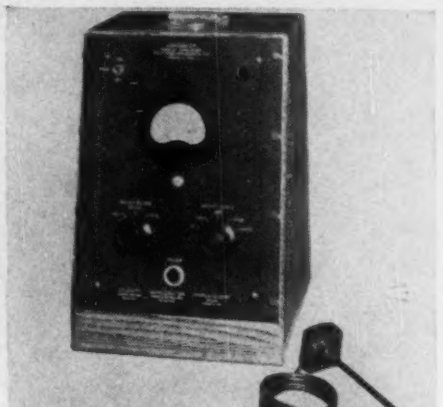
SORENSEN & COMPANY
5 & COMPANY

SORENSEN & COMPANY, INC.
STAMFORD, CONN.

60-cycle motor operating at 3,600 rpm has a starting torque of 0.75 ounce/inches, weighs 18 ounces and will be useful for record changers, wire and tape recorders, and instrument product applications.

Vibration Meter

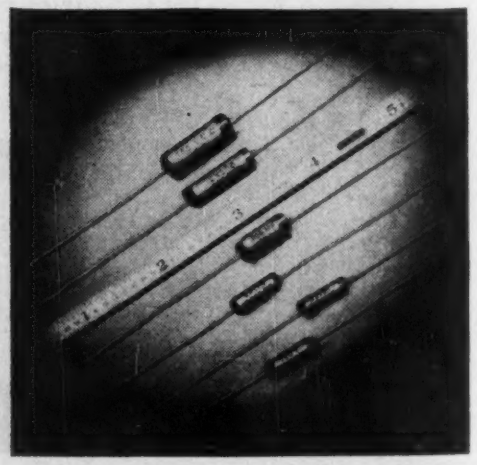
TELEVISO PRODUCTS CO., 7466 Irving Park Road, Chicago 34, Ill. The model 11-B Vibrometer consists of a search probe attached by cable to a vacuum tube voltmeter. The meter



responds to frequencies from 5 to 2,500 cycles and can be read in terms of displacement, velocity, and acceleration. Displacements under 0.01 inch and accelerations up to 10,000 can be measured. The equipment is completely described in Bulletin 33.

Midget Capacitors

CORNELL-DUBILIER ELECTRIC CORP., South Plainfield, N. J. A new line of midget capacitors, types ZY and ZZ, are among the smallest cylin-



A little-known property of Nickel keeps temperatures right in the SIMMONS ELECTRONIC BLANKET

Acting as the temperature-sensitive element in an electronic control is a new use for Nickel.

Here's how the job is carried out in the Simmons Electronic Blanket:

In the embedded gridiron pattern of heating wires is 355 feet of fine Nickel wire. Acting as a "feeler," it constantly measures blanket temperature.

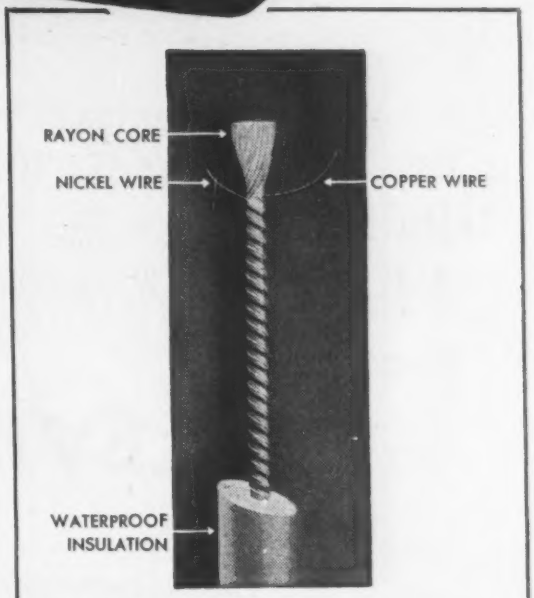
If temperature falls below a chosen level, the decreased resistance of the Nickel wire instantly transmits a signal to the control box. There, electronic tubes amplify the signal, making it strong enough to actuate a relay that sends current through the heater wires.

Once the chosen temperature has been restored, signals from the "feeler" wire similarly shut off the current.

Nickel was selected for this job because its coefficient of electrical resistivity is higher than that of any other commercial metal—.0043-.0050 (68-212° F.). But, as so often occurs when Nickel or Nickel Alloys are used, there were contributing advantages. Nickel offers fatigue resistance *(needed to withstand repeated flexing)*. Nickel is rustless and corrosion resisting *(important, since the blanket must be washable)*. Nickel is both workable and strong *(the "feeler" wire is only 0.0037" in diameter)*.

***Remember to investigate* Nickel and INCO Nickel Alloys whenever you need metals with a *combination* of hard-to-find properties.**

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.



THE HEATING ELEMENT

Shown above is the heating element of the Electronic Blanket made by the Simmons Company. Floating in channels inside the blanket, it is composed of two conductors, each insulated from the other by enamel and both covered by an over-all jacket of waterproof plastic insulation. One conductor is the heating wire. The other conductor, consisting of 355 feet of fine Nickel wire, acts as a "Feeler" and constantly measures blanket temperature.

Nickel plays an important role in the control box, too. For, with 3 electronic tubes used, there are jobs that can be done only by Nickel . . . jobs like the anodes, grids, supporting rods and lead-ins, which require Nickel's great thermal endurance, strength and corrosion resistance.

Nickel NICKEL (INCO TRADE MARK) ALLOYS MONEL* • "K" MONEL* • "S" MONEL* • "R" MONEL* • "KR" MONEL* • INCONEL* • NICKEL • "L" NICKEL* • "Z" NICKEL*
*Reg. U. S. Pat. Off.

CBS Photo

TELEVISION - IT'S HERE!

(Quoting—Television Broadcasters Association)

Here's Your Opportunity to "get in on the ground floor" and prepare for great opportunities ahead

NOW—for the First Time, CREI Offers a Complete Streamlined Home Study Course in

Practical

TELEVISION

Engineering

FOR THE PROFESSIONAL RADIOMAN

Here is the basic, practical type of engineering training that will qualify you for a "key" job in the expanding Television industry. Sooner or later you *must* face Television—as a problem, or as an opportunity. You can't rest on your past radio experience. But, you can use it as a firm foundation, upon which you can add greater knowledge and ability with the help of this new CREI home study course. It costs you nothing but a few minutes' time to get complete details. Write at once for FREE DETAILS of the Television Engineering Course.

CAPITOL RADIO ENGINEERING INSTITUTE

Dept E-12, 16th and Park Road, N. W., Washington 10, D. C.

Just Off the Press! **Mail Coupon for Complete Free Details and Outline of Course**

If you have had professional or amateur radio experience and want to prepare for opportunities in TELEVISION, let us prove to you we have the training you need to qualify. To help us intelligently answer your inquiry—PLEASE STATE BRIEFLY YOUR BACKGROUND OF EXPERIENCE, EDUCATION AND PRESENT POSITION.

E-12

GENTLEMEN: Please send me your free booklet, "Your Opportunity in the New World of Electronics", together with full details of your home study training. I am attaching a brief resume of my experience, education and present position.

Name .....

Street .....

City ..... Zone..... State.....

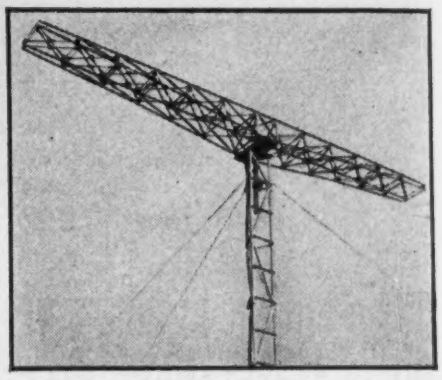
CHECK ☐ PRACTICAL RADIO ENGINEERING
COURSE ☐ PRACTICAL TELEVISION ENGINEERING
☐ I am entitled to training under the G. I. Bill.

Member Natl. Home Study Council—Natl. Council of Technical Schools—Television Broadcasters Assn.

drical units ever manufactured. Standard ZY units are ¾ inch long and not over 9/32 inch in diameter. Capacitance values range from 0.001 to 0.03 microfarad at d-c rated voltages from 150 to 600 volts. The ZZ units are smaller and have correspondingly lower maximum values of capacitance and voltage breakdown.

Rotary Beam

WIND TURBINE CO., West Chester, Pa. The new Trylon rotary beam antenna support can be used for a 4-element amateur 20-meter directive antenna or for any other high-



frequency array that may be required in special receiving installations. Overall length of the support is about 19 feet, but it weighs only 31 pounds. Ball-bearing design allows the use of either manual or motor drive.

Insulating Tubing

INSULATION MANUFACTURERS CORP., 565 W. Washington Blvd., Chicago 6, Ill. Dieflex tubing products are made from braided cotton or braided glass and so treated that they will not fray. Silicone-treated Fiberglas varnished tubings are also available.

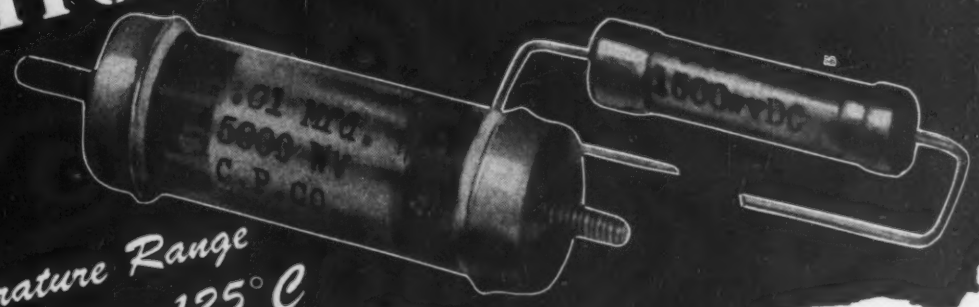
V-T Voltmeter

GENERAL RADIO CO., 275 Massachusetts Ave., Cambridge 39, Mass. The type 1800-A vacuum-tube voltmeter supersedes the type 726-A. It can be used to measure either d-c or frequencies up to 500 megacycles. A probe used with a variety of fittings has a minimum capacitance

PLASTICON* ASG Silicone-Filled GLASSMIKES

1-3/8 x 3-1/2

FOR HIGHER VOLTAGES



Extreme Temperature Range from Minus 60° C to Plus 125° C

From 600 to over 30,000 Volts

Modern functionally designed capacitors. Metal ferrules are soldered to silver bands fused to each end of heavy-walled glass tubes. This vacuum tight assembly is fungus-proof and passes Signal Corps, Air Corps and Navy thermal cycle and immersion tests.

Applications

- **For low and medium power coupling and bypass circuits where mica capacitors have previously been required**
- **Television and Oscilloscope Circuits**
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Write for illustrated literature featuring our complete line of Glassmike Capacitors.

***PLASTICONS: Plastic-Film Dielectric Capacitors**

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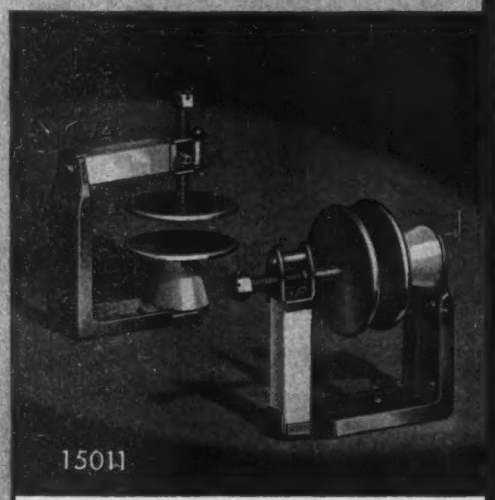
Designed for

M

Application

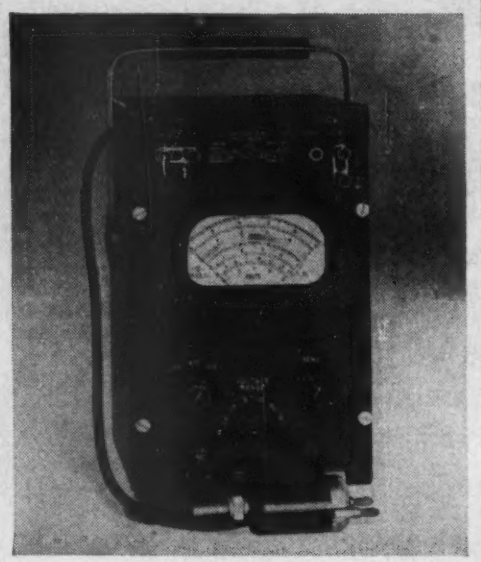


Disc Type
Neutralizing Capacitor

Designed originally for use in our own No. 90881 Power Amplifier, the No. 15011 disc neutralizing capacitor has such unique features as rigid channel frame, horizontal or vertical mounting, fine thread over-size lead screw with stop to prevent shorting and rotor lock. Heavy rounded-edged polished aluminum plates are 2" diameter. Glazed Steatite insulation.

JAMES MILLEN MFG. CO., INC.

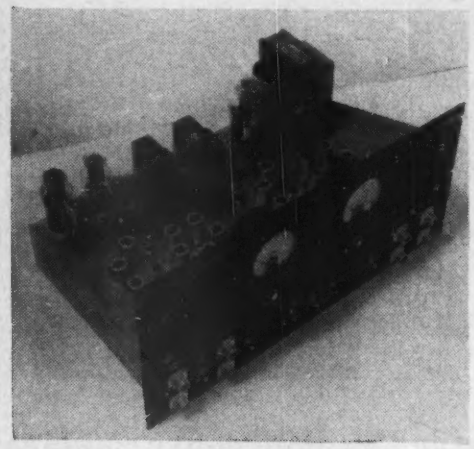
MAIN OFFICE AND FACTORY
MALDEN
MASSACHUSETTS



of 3.1 micromicrofarads and an input resistance at low frequencies of 25 megohms. The regulated power supply contained in the instrument is operated from the power lines.

Decade Counter

GENERAL ELECTRIC CO., Syracuse, N. Y. A new decade scaling unit for use with particle detectors will respond to impulses of 0.1 micro-



second duration separated by only 10 microseconds. Scaling factor of the type YYZ-1 unit is either 10 or 100, but can be used in cascade to provide factors of 1,000 or more.

Microvolt Meter

THE PERKIN-ELMER CORP., Glenbrook, Conn. An amplifier for the measurement of d-c and low-frequency a-c voltage in the microvolt range operates by changing direct voltages into 80-cycle alternating voltage by means of a vibrator. After this voltage has been ampli-

Suretake Sam Says:

Whether you are recording for broadcast, rebroadcast, audition, or movie playback, it is a satisfaction to know that the disc you use will not fail.

Soundcraft's great disc names:
- 'Broadcaster'
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are your guarantee of highest professional quality.

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NEW YORK 22, N. Y.
PROGRESS ALONG SOUND LINES

DIELECTRIC-HEATING ENGINEERS

wrote the specifications for this tube!

- ✔ High plate voltage to match high-impedance load.
- ✔ Low-wattage, low-current filament, for simple and economical transformer and circuit design.
- ✔ Up to 50 mc frequency at max plate input.
- ✔ Over 6 kw tube typical power output (Class C operation).
- ✔ Modern, compact tube and radiator construction, to conserve space when tube is mounted.

GL-5549
RATINGS

No. of electrodes	3
Type of cooling	forced air
Filament voltage	12.6 v
Filament current	56 amp
Max anode ratings:	
voltage	8,500 v
current	1.25 amp
input	10 kw
dissipation	4 kw
Frequency at max ratings	50 mc

New POWER TRIODE

GENERAL ELECTRIC's new GL-5549 triode bulls-eyes the target for power tubes for dielectric heating. Check all 5 key advantages above—then add (6) forced-air cooling for simplicity of installation, (7) a pure tungsten filament for more reliable high-voltage performance.

Substantial service life may be ensured by lowering the voltage of the GL-5549's tungsten filament during periods when no anode power is needed. Circuitwise, this easily is accomplished by using an auxiliary contact on the anode voltage contactor, to cut back the filament potential to 80 percent normal when the anode is "idle". The practice is especially useful in dielectric heating applications, which commonly operate on a low duty-cycle basis.

Type GL-5549 is the newest of a group of G-E power tubes for high-frequency heating—18 types in all—which is unexcelled in range, adaptability, and proven performance. G-E tube engineers gladly will work with you to select *the right tube* for your individual heating-equipment problem. Phone your nearest G-E office, or write *Electronics Department, General Electric Company, Schenectady 5, N. Y.*

GENERAL ELECTRIC

192-E1C-6850

FIRST AND GREATEST NAME IN ELECTRONICS

MICRODIMENSIONAL

WIRE & RIBBON

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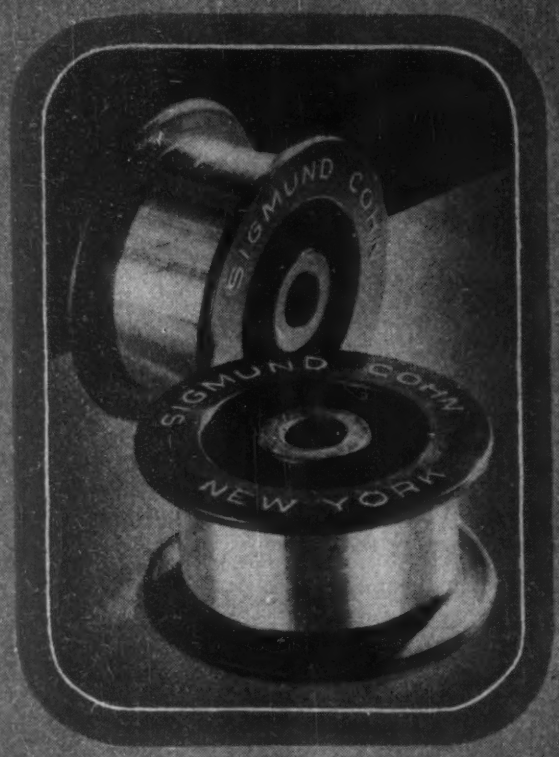

Wires drawn to .0004" diameter

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Ribbon rolled to .0001" thickness

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Special Alloys for individual requirements

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WRITE for list of stock alloys

SIGMUND COHN & CO.

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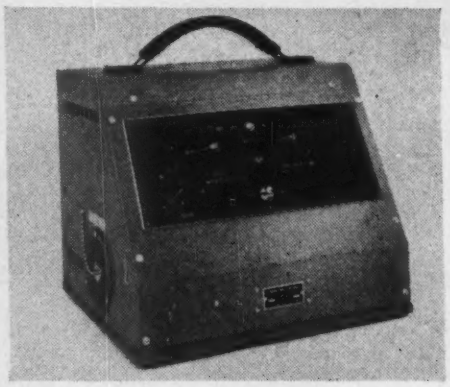
SINCE 1901

fied in a resistance-capacitance amplifier it is converted back to d-c through the synchronous action of other vibrator contacts. Because the output voltage can be used to



operate rugged meters or standard recorders, the amplifier is suitable for measuring circuits of radiation thermopiles, infrared spectrometers, and thermocouples.

All-Band Receiver

COLLINS RADIO CO., Cedar Rapids, Iowa. The 75A receiver is not a general communications receiver, having been designed for amateur band coverage from 80 to 10 meters. The straight-line tuning dial is cali-

brated directly in frequency. Circuitwise, the receiver includes a crystal filter, double conversion and self-contained power supply. It is completely described in a four page bulletin.

Improved B Battery

NATIONAL CARBON CO., 30 E. 42nd St., New York 17, N. Y. New 45-volt B batteries for use with electronic communications and industrial equipment are now available in smaller physical size. The new Mini-Max type battery displaces only 76.6 cubic inches as compared

American Beauty

ELECTRIC SOLDERING IRONS

are sturdily built for the hard usage of industrial service. Have plug type tips and are constructed on the unit system with each vital part, such as heating element, easily removable and replaceable. In 5 sizes, from 50 watts to 550 watts.

•

TEMPERATURE REGULATING STAND

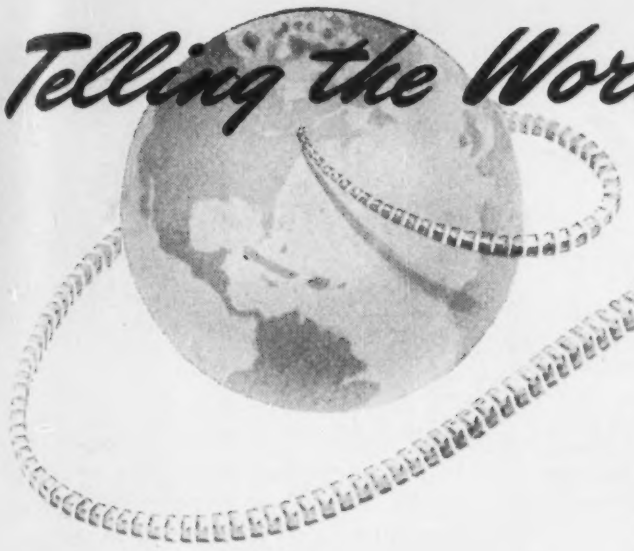
This is a thermostatically controlled device for the regulation of the temperature of an electric soldering iron. When placed on and connected to this stand, iron may be maintained at working temperature or through adjustment on bottom of stand at low or warm temperatures.

For descriptive literature write 111-1

AMERICAN ELECTRICAL HEATER COMPANY

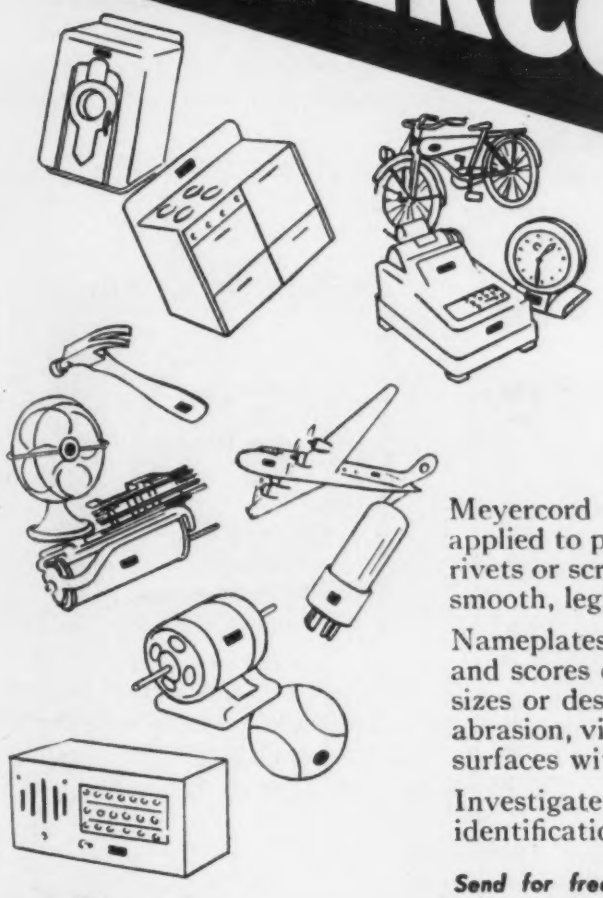
DETROIT 2, MICH., U. S. A.

Telling the World it's a REMINGTON



with

MEYERCORD DECALS



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Electricity

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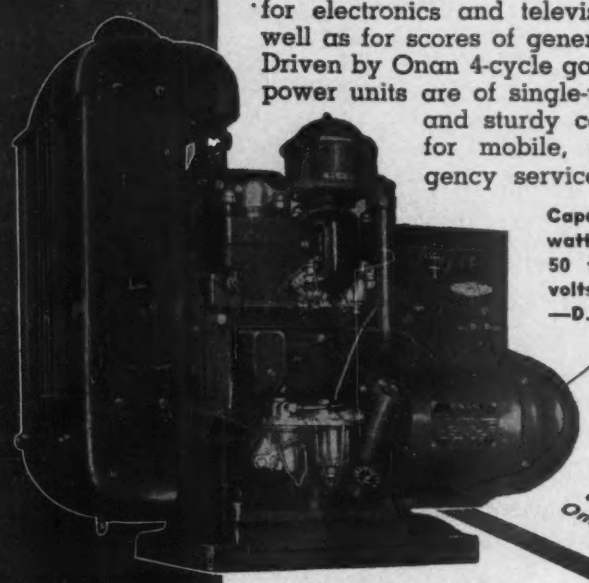
Onan ELECTRIC PLANTS

ONAN ELECTRIC GENERATING PLANTS supply reliable, economical electrical service for electronics and television applications as well as for scores of general uses.

Driven by Onan 4-cycle gasoline engines, these power units are of single-unit, compact design and sturdy construction. Suitable for mobile, stationary or emergency service.

Capacity range: 350 to 35,000 watts; 115 to 660 volts A.C., 50 to 800 cycles; 6 to 500 volts D.C.; combination A.C. —D.C. types.



Write For Folder 690 describing complete Onan Line

Model shown is from W2C series: 2000 to 3500 watts, powered by Onan two-cylinder, water-cooled engine

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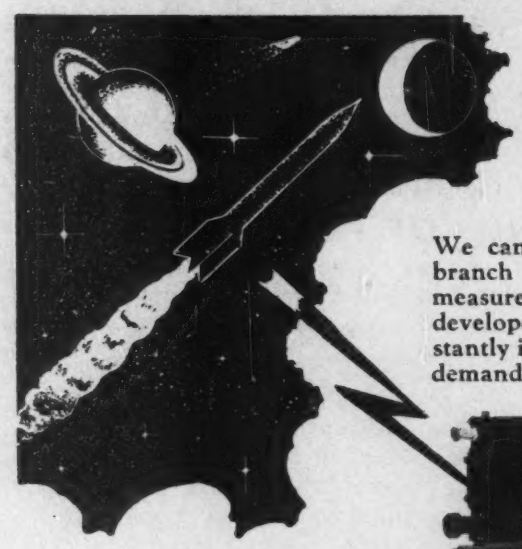
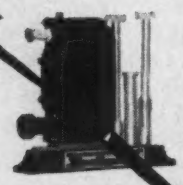


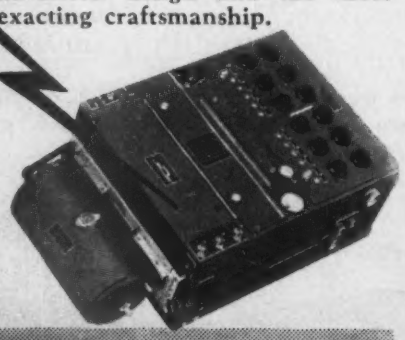
Instruments for **MODERN RESEARCH** by *Hathaway*

We can venture into the UNKNOWN in any branch of research only as fast as we can measure. New Hathaway instruments are being developed and standard designs are being constantly improved to keep abreast of the expanding demands of modern research.



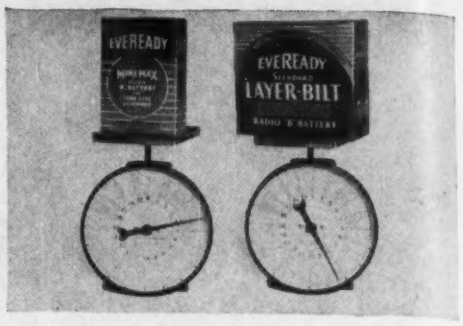
Whatever may be your needs in OSCILLOGRAPHIC recording equipment, Hathaway has instruments to meet them. You can rest assured that you will find in ANY Hathaway instrument the most advanced design and the most exacting craftsmanship.

- **Type S8-B and S8-C Oscillographs,** 12 to 36 elements for uses in field and laboratory.
- **Type S12-A Oscillographs,** 12 elements, where light-weight and extreme portability are a must.
- **Type S14-A Oscillograph,** 6 to 12 elements. Complete, low cost Student's oscillograph.
- **Galvanometers** of advanced design, recording to 5 and 10 kilocycles.



Write for technical bulletins. Hathaway Instrument Co., 1315 S. Clarkson St., Denver 10, Colorado.

Hathaway INSTRUMENTS

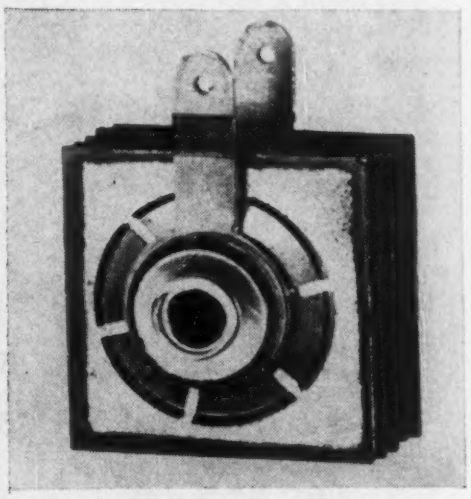


with 179 for the older type and weighs 4 pounds 4 ounces as compared with over 8 pounds. Power capability and life of the new battery are the same as with the larger type.

•

Miniature Rectifier

RADIO RECEPTOR CO., INC., 251 West 19th St., New York 11, N. Y. A new miniature five-plate selenium rectifier, type 5M1, has been designed to replace rectifier tubes in a-c/d-c portable radio receivers. The rectifier is used with a series



25-ohm resistor and a 40-μf capacitor. Maximum current is 100 milliamperes up to 35 C for input and output voltages of 130 volts.

Television Kit

TRANSVISION, INC., 144 Union Ave., New Rochelle, N. Y. Reminiscent of the early days of shortwave reception is the type of package offered for the television novice. A complete 17-tube television receiver with a 7-inch picture tube is offered in kit form. A bare minimum of tools is needed, but no testing equipment is required, since all dif-

Music rides the rails

Now! Farnsworth brings top-quality music and radio entertainment to modern passenger trains!

NOW! Progressive railroads can offer the traveling public the same high quality of music and entertainment enjoyed in their passengers' own homes. With this new service, railroads can pave the way to greatly increased passenger train luxury and revenue.

In offering the first practical electronic program distribution system, Farnsworth has met the three basic requirements which railroad-conducted studies have shown necessary to high-quality rail-borne entertainment: (1) uniform, low-level sound distribution; (2) automatic compensation for varying ambient noise levels; (3) programs that passengers want to hear.

In the de luxe Farnsworth systems four channels are available for individual selection: popular or luncheon music; semi-classical or dinner music; radio programs; train announcements and travel talks. Also available are more simplified single- or dual-channel systems.

All Farnsworth systems are simple to install; operate automatically and unattended. Unitized construction permits instantaneous replacement of units without manual disconnection of a single wire. Other noteworthy features are: push-button precision crystal radio tuning and self-rewinding wire reproducing mechanisms.

Farnsworth Passenger Program Distribution Systems have been engineered by the same laboratories that gave the world its finest instrument for musical reproduction — The Capehart.

Farnsworth Television & Radio Corp., Dept. E-12, Fort Wayne 1, Indiana.

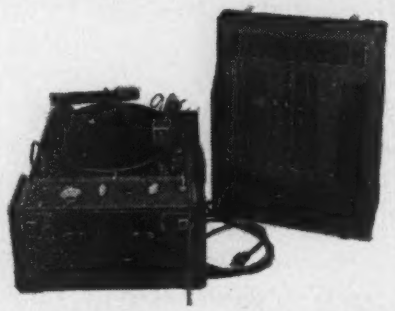
Farnsworth

Television · Radio · Phonograph-Radio

Farnsworth Radio and Television Receivers and Transmitters • Aircraft Radio Equipment • Farnsworth Television Tubes • Halstead Mobile Communications and Traffic Control Systems for Rail and Highway • The Farnsworth Phonograph-Radio • The Capehart • The Panamuse by Capehart

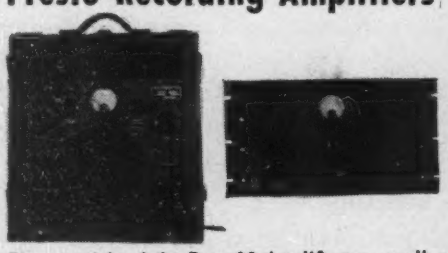
HARVEY
FOR RECORDING EQUIPMENT

Presto Model K8 Recorder



A portable unit for instantaneous recording, public address and record playing. Records 15 minutes continuous on a 13¼" disc at 33⅓ r.p.m. Makes 6, 8, 10 and 12 inch records from mike or radio set input. Separate recording and playback heads, built-in amplifier and speaker. Compact and light for carrying. Plug into any 110-volt, 60 cycle AC line. Mike, needles and discs not included.
$297.00

Presto Recording Amplifiers



Three models of the Type 85 Amplifier are available. The 85 is a high quality recording amplifier with ample reserve power supply to operate Presto radio tuners and pre-amplifiers. It has a gain of 90 db. with a frequency response flat from 30 to 15,000 cycles. The power output is 10 watts and both output and input impedances are 500 ohms.

A master selector switch provides switching for public address, microphone recording, playback, radio recording and radio playing and switches to either of two tables for continuous recording.

85-A portable model contains an 8" monitor loud speaker and panel connections for two turntables, pre-amplifier and radio tuner.....**$272.00**

85-B is for rack mounting and connections are brought out to a terminal strip at the rear of the chassis.....**$272.00**

85-E is portable and identical with the 85-A except that it has a manually operated high frequency equalizer for 33⅓ r.p.m. recording.
$357.00

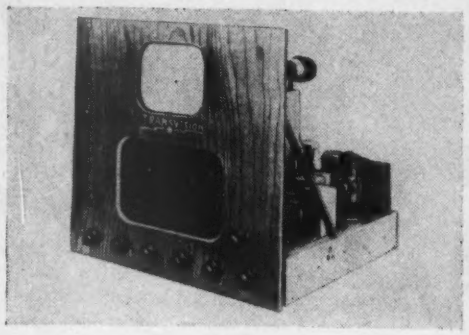
NOTE: All prices quoted are NET, FOB New York and subject to change without notice.

Harvey is an Authorized Presto Dealer

Telephone: LOngacre 3-1800

HARVEY RADIO COMPANY INC.

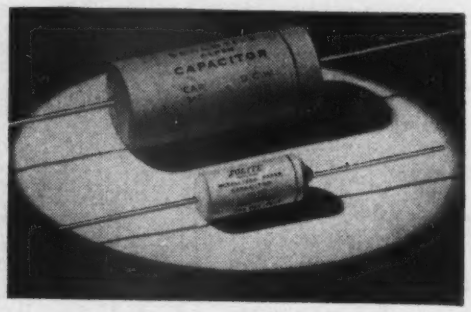
103 West 43rd St., New York 18, N. Y.



ficult assemblies are prewired and tuned. Front panel and chassis with safety interlock, are supplied. A dipole antenna, 60 feet of lead-in cable, and a wooden mast are also included. Arranged for assembly by nontechnical television enthusiasts, the kit sells for $139.50, f.o.b. New Rochelle.

Metallized Capacitor

SOLAR MFG. CO., 285 Madison Ave., New York 17, N. Y. Solite paper capacitors are a new development using an aluminum film of negligible thickness deposited directly on the dielectric. Because of the self-healing characteristics which

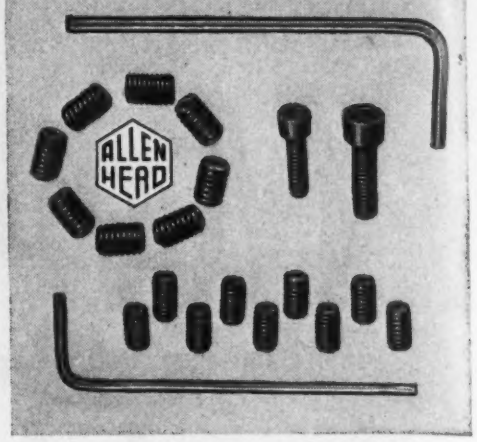


guard against permanent short circuit after breakdown, the capacitors can operate at higher voltages. The new capacitors are physically small, have long life, low power factor, excellent r-f characteristics and are interchangeable with present standard capacitors when they are operated within published ratings.

Power Amplifier

JAMES MILLEN MFG. CO., INC., Malden, Mass. A packaged r-f power amplifier unit for use with amateur or other high-frequency equipment, the No. 90881 amplifier is wired for a pair of type 812 tubes, and contains grid and plate tank circuits as well as controls and meters. Plug-in inductors for the amateur

ALLEN



Hex-socket screws in numbered sizes

extra-dependable
for electronic devices

Tiny hex-socket Cap Screws and Set Screws steeled to stand amazingly tight set-ups. Cap Screws in the numbered sizes from 1 to 10 inclusive; Set Screws from No. 2 to 10.

The Cap Screws are *Allen "pressur-formd"* for maximum strength of head and socket. This process makes the steel-fibres conform to the shape of the head, — no cut fibres. Threads also formed by pressure-process to a high Class 3 fit, ensuring a high degree of frictional holding-power.

The Set Screws have die-cut threads accurate to a high Class 3 fit, with perfectly-formed hex sockets. The screws can be held on either end of the handy hex keys and turned into the tapped hole without fingering. Allen Hand Drivers are available to facilitate fast assembling.

In radio and television sets, radio telephones, radar equipment, electronic controls, these screws HOLD fine adjustments and intricate assemblies.

Order of your local Industrial Distributor

THE ALLEN MFG. CO.,
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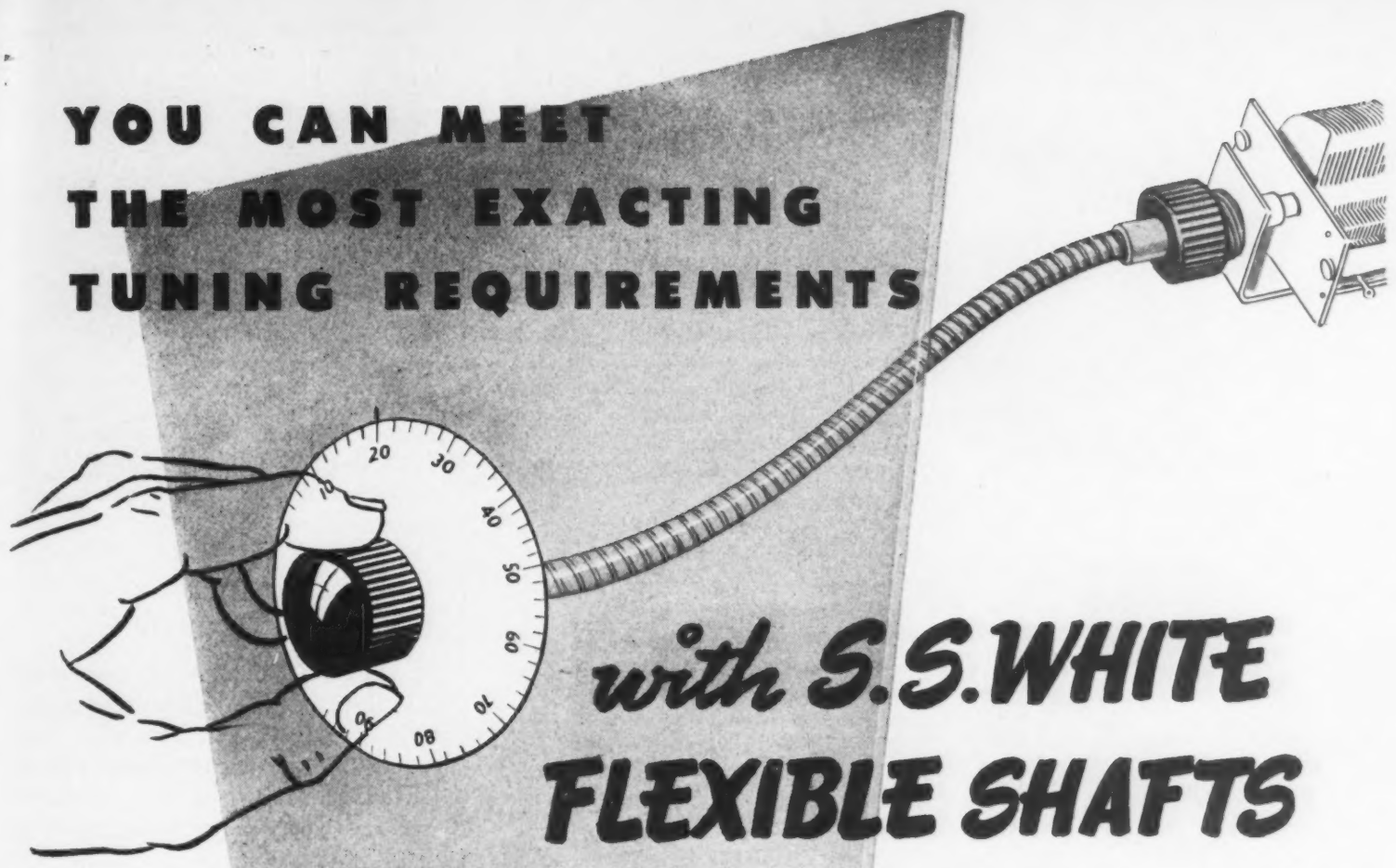
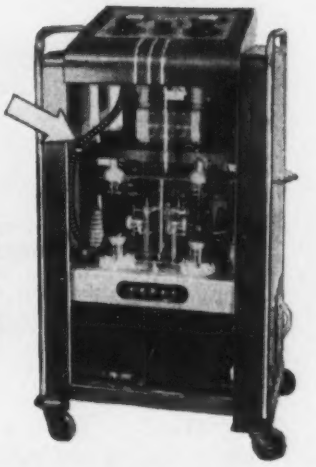
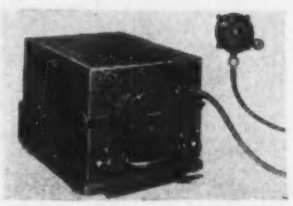
YOU CAN MEET THE MOST EXACTING TUNING REQUIREMENTS



with S.S.WHITE FLEXIBLE SHAFTS



Flexible shafting in this diathermy unit transmits smooth sensitive control between a variable circuit element and its control knob.



In this Airplane Radio Receiver up to 50 feet of flexible shafting has been used in conjunction with gearing to obtain extremely fine adjustments.

S.S.White flexible shafts are specifically designed for sensitive tuning. They are designed and built to give minimum deflection when the shaft is turned in either direction. And through the use of simple gearing, practically any degree of sensitivity can be obtained regardless of length of shaft required.

Hundreds of applications have proved that, when properly applied, S.S.White flexible shafts work as smoothly and sensitively as a direct connection. Striking testimonial to this is given by the chief engineer of a large electrical equipment manufacturer who says an S.S.White remote control flexible shaft gives his product "a smooth range of speed control with **facility of adjustment equal to that of a micrometer.**"

There is a large selection of S.S.White flexible shafts available to meet a wide variety of requirements. Electronic engineers will find it worthwhile to know their range and scope.

WRITE FOR BULLETIN 4501—It gives essential facts and engineering data about flexible shafts and their application. Write for your copy today.

S.S.WHITE INDUSTRIAL DIVISION

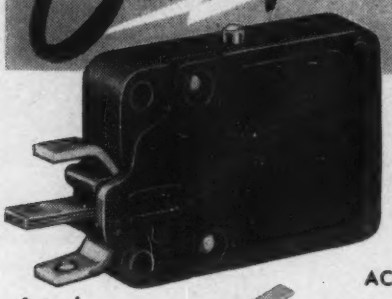
THE S. S. WHITE DENTAL MFG. CO.

DEPT. E, 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS • FLEXIBLE SHAFT TOOLS • AIRCRAFT ACCESSORIES
SMALL CUTTING AND GRINDING TOOLS • SPECIAL FORMULA RUBBERS
MOLDED RESISTORS • PLASTIC SPECIALTIES • CONTRACT PLASTICS MOLDING

One of America's AAAA Industrial Enterprises

Compact for MODERN DESIGN



Actual Size

With A-18 leaf bracket

With A-18-M roller leaf bracket

This new, basic Model "M" ACRO Switch is the ultimate in compactness, with overall dimensions only 1 5/8" x 53/64" x 9/32". Four 3/32" mounting holes. Built with ACRO's patented Beryllium Rolling Spring and used by scores of the nation's leading manufacturers of electrical products. Approved by Underwriters' Laboratories. Rating: 10 amps. 125 volts A. C. Contact arrangements, single pole, normally open, normally closed or double throw. Furnished with standard leaf bracket actuators as illustrated or made to special design. For quicker reply on special actuators or characteristics please give full engineering details.

ACRO ELECTRIC COMPANY
1316 SUPERIOR AVENUE • CLEVELAND 14, OHIO

The FINEST MICROPHONES for P.A. and RECORDING!

AMPERITE VELOCITY MICROPHONE WITH PATENTED ACOUSTIC COMPENSATOR

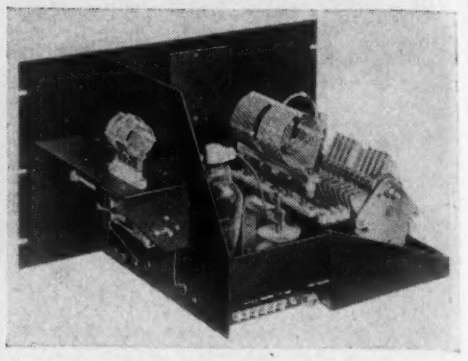
New P.G. DYNAMIC WITH NEW SUPERIOR ELIPSOID PICK UP PATTERN!

AMPERITE KONTAK MIKES
IDEAL FOR AMPLIFYING STRINGED INSTRUMENTS
USED WITH ANY AMPLIFIER AND WITH RADIO SETS

ASK YOUR JOBBER . . . WRITE FOR FOLDER

AMPERITE

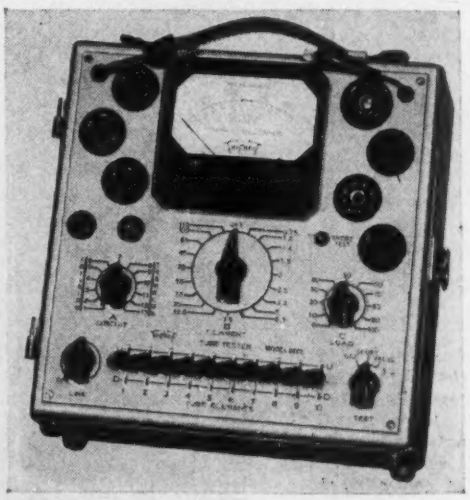
561 BROADWAY NEW YORK



bands from 10 to 80 meters are furnished. The assembly is mounted on a 10½-inch relay rack panel.

Dynamic Tube Tester

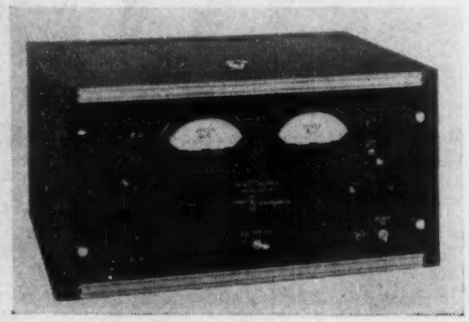
TRIPLETT ELECTRICAL INSTRUMENT Co., Bluffton, Ohio. The new model 2425 mutual conductance tube tester uses a calibrated measuring instrument that gives readings directly proportional to the value in



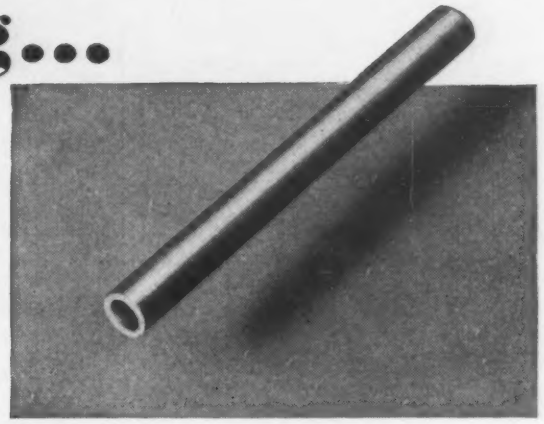
micromhos. Short, open, and gas tests can also be made. The instrument is contained in a metal carrying case 10x10x5¾ inches.

Regulated Power Supply

FURST ELECTRONICS, 800 W. North Ave., Chicago 22, Ill. The model 310-A regulated power supply is



When men in Electronics talk of Tubing...



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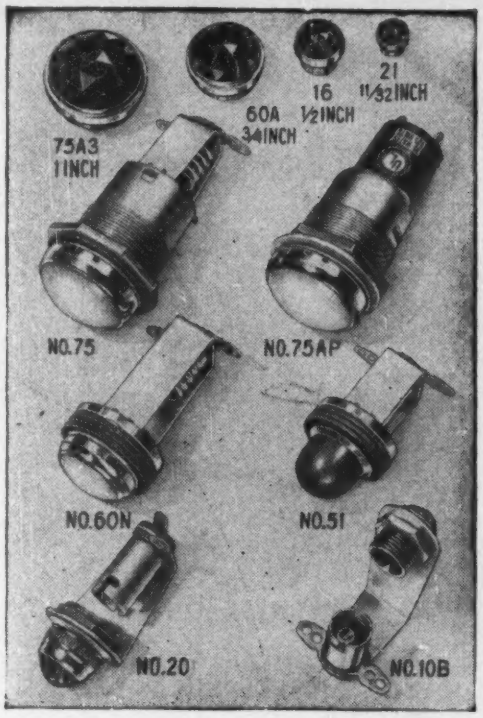

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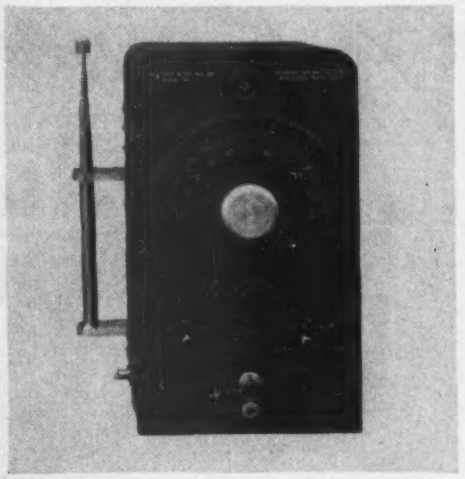
arranged for testing a-c/d-c equipment and gives continuously variable voltage from the a-c power line directly, or through a rectifier that maintains voltage constant within 1 percent regardless of line or load variations. An a-c voltage of 1 ampere and d-c output up to 450 milliamperes are available. The model 310-B equipment does not include a-c controls or meter. Price of the 310-A unit is $330.

Frequency Meter

BROWNING LABORATORIES, INC., 742 Main St., Winchester, Mass. The model S-6 frequency meter covers the range from 100 kilocycles to 50



megacycles with an accuracy of plus or minus 0.025 percent. An internal crystal calibrator provides long-time accuracy. The equipment, operated from socket power, weighs 15 pounds.

Variable Equalizer

BURNELL & Co., 10 Van Cortlandt Ave., New York 58, N. Y. A new

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. . . Impromptu Discussions about Miniature Tubes

". . . we'll get your trains running, Junior, but I want to tell Uncle John why the pentagrid tube is used in more than 90% of all receivers . . . it's because the superheterodyne circuit outperforms all others, you know, and the pentagrids give you 'sure-fire' frequency conversion.

"And they are better, too. You know, the failure of the oscillator will gum up the work of a converter. Well, these TUNG-SOL BE6's are designed with 60% greater oscillator capability than big tubes. Furthermore, lower interelectrode capacitance, and shorter lead lengths permit stable oscillation well over 100 megacycles.

"Although only a minor improvement in conversion transconductance is designed into the BE6's, they tolerate wider variations in both oscillator and R. F. circuit designs and still come up with top performance. They maintain the typical negative input impedance of the pentagrid construction so useful at moderately high frequencies. Coupling between signal and oscillator grids is just as easy to neutralize.

"As modulators the BE6's are on their 'home grounds,' for either single, balanced, or reactance modulation circuits. As mixers, with separate excitation, their high frequency performance is excellent. The two control grids in one structure give you a lot of other circuit variations. As low level audio amplifiers, it is feasible through use of the 're-entrant' type of circuit to get higher gains than you usually get with one tube.

"Sure, TUNG-SOL has a corps of service engineers. They will be glad to tell you how you can get better results with the BE6's . . . consultation with them is always confidential . . . yes, Junior, we know they are your trains—we'll have them running in a minute but . . ."

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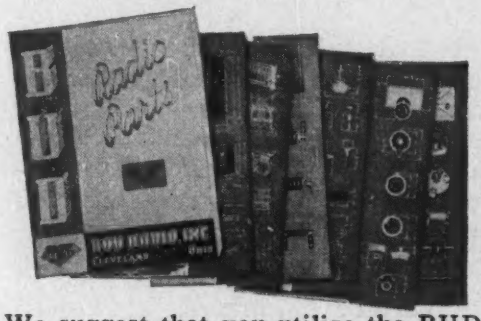

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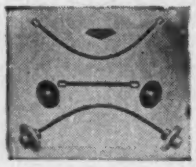

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This heavy duty R.F. transmitting choke is especially intended for use in high powered transmitter plate circuits. All chokes are coated with a moisture absorbtion preventing ceramic coating. Momentary overload may be withstood without collapsing individual pies.

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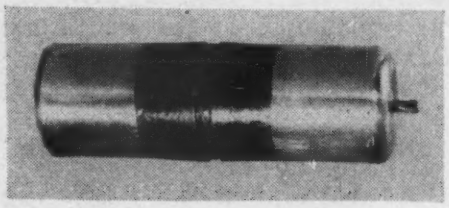
CLEVELAND 3, OHIO

type of equalizer for use in broadcast and sound work has been designed so that a given curve of equalization can be preset by an external variable resistor. The units have operating impedances of 500 or 10,000 ohms. Low end of the equalizer operates between 30 to 120 cycles, with 5 to 15 kilocycles at the high end.

Mercury Switch

MERCONTROL INC., 278 Pearl St., New York 7, N. Y. The type D-100 all-metal mercury switch has a continuous current rating of 100 amperes at 110 or 220 volts, a-c or d-c. The metal enclosure is hermet-



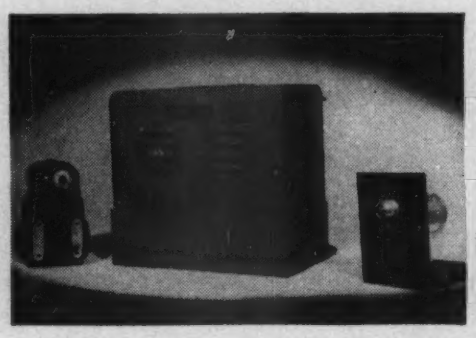
ically sealed to the ceramic insulation so that the switch can be used with safety in atmospheres where switch sparking is a hazard.

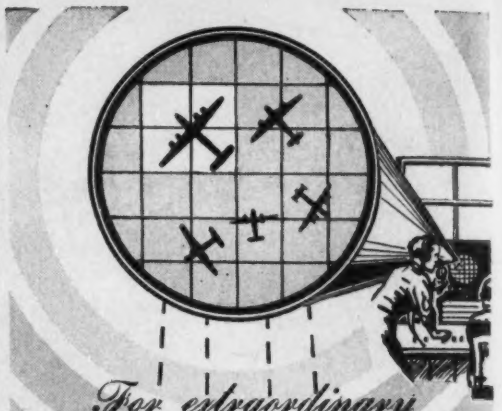
Precision Bearings

MINIATURE PRECISION BEARINGS, INC., Keene, N. H. Angular contact bearings that can be used to take a radial or thrust load are available in small sizes suitable for small motors, computers, or electronic equipment. Other types of superlight bearings with bore as small as ⅛ inch are also immediately procurable.

Remote Control

G. C. WILSON & Co., 2 North Passaic Ave., Chatham, N. J. A new servo for remote indication or con-





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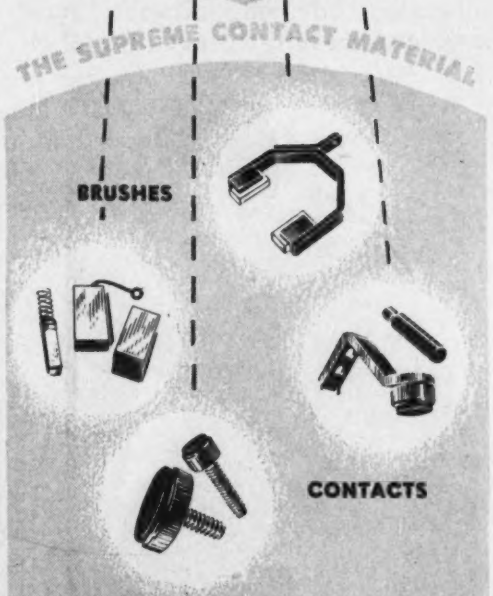

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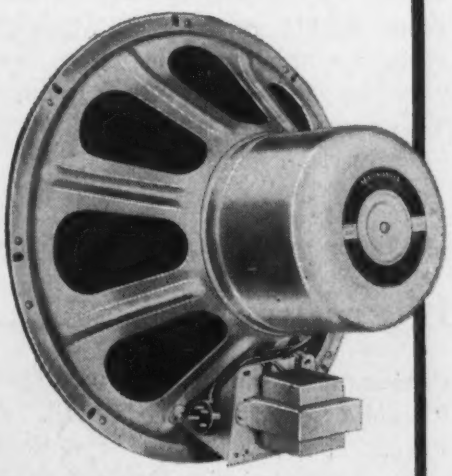

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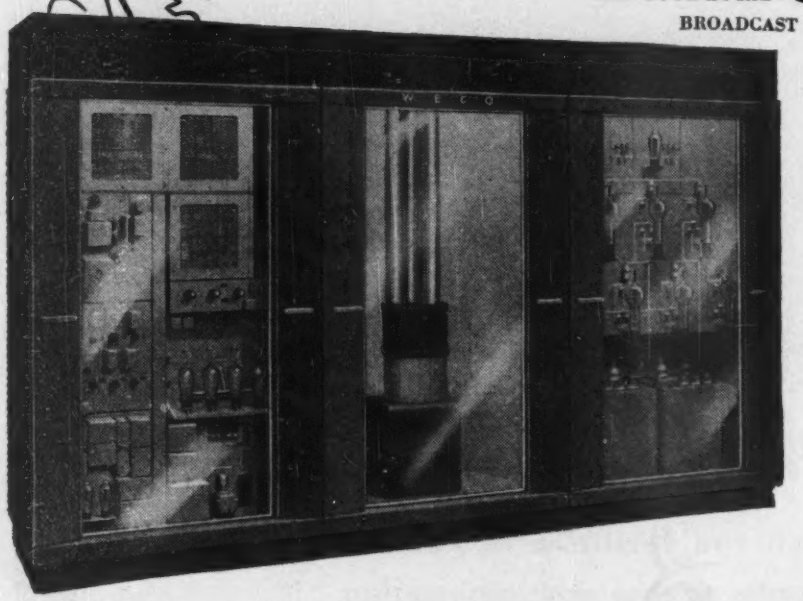

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Close tolerance units for precision performance

IN-RES-CO resistors are engineered to meet all important electronic application needs. They are wire wound for permanent, exact resistance value and both inductive and non-inductive types are standard. Standard tolerances are 1 and 2%—closer tolerances on special order. Rigid quality control assures a uniform standard of excellence and modern manufacturing facilities result in low unit cost and prompt delivery. Manufacturers of electrical and electronic instruments and equipment should investigate the advantages of designating IN-RES-CO as their exclusive wire wound resistor source.

TYPES RN AND SN Tropi-pruf resistors—RN: 3/4" long x 5/8" dia., Max. Res. 1/2 Megohm, 1/2 watt; SN: 1-3/16" long x 5/8" dia., Max. Res. 1 Megohm, 1 watt

IN·RES·CO

INSTRUMENT RESISTORS CO.
1036 COMMERCE AVE. UNION, N. J.

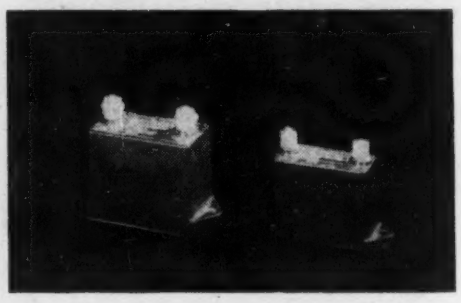
trol comprises the torque unit, amplifier, and control unit illustrated. The torque unit shaft responds to the position set by the control unit to an accuracy of 1 percent. One ounce-inch of operational torque results in 50 pound-feet of output torque.

VHF Tetrode

UNITED ELECTRONICS Co., 42 Spring St., Newark 2, N. J. The type 5562 graphite-anode beam tetrode can be used with full power output up to 120 megacycles. It has a thoriated tungsten filament operating at 6.3 volts. As a class C telegraph power amplifier or oscillator in typical operation, it uses 1,500 volts on the plate, can be driven with less than 4 watts, and has a power output of 135 watts.

Blocking Capacitors

GENERAL ELECTRIC Co., Schenectady 5, N. Y. New Lectrofilm capacitors in case styles 65 and 70



have been announced for radio-frequency blocking and bypass use. In the case 65 style four ratings from 0.0001 microfarad at 3,000 volts d-c are available. The case 70 styles have high voltage ratings. These capacitors are described in bulletin GEA 4295A.

Literature

Cables and Connectors. American Phenolic Corp., Chicago 50, Ill. A 12-page bulletin describes various sorts of transmission line and cable as well as cable fittings and connectors particularly useful at high radio frequencies. A separate

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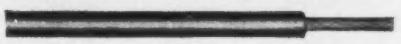
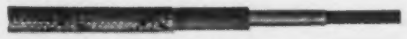


Asbestos Insulated Lead Wire

Heatproof and flame-resistant, this wire will not bake brittle or crack; won't rot, swell or flow when in contact with oil or grease, and has ample moisture resistance for most applications. Sizes 22 to 4 AWG with solid or stranded copper monel or nickel conductors insulated with black, white or colored impregnated asbestos. Braid-covered also.



Rockbestos Firewall Hookup Wire

For radio, television, calculators, amplifiers or small motor, coil, dynamotor and transformer leads. Insulated with high dielectric tapes and impregnated felted asbestos, and covered with color-coded lacquered glass braid, this wire has a maximum operating temperature of 125°C. No. 22 to 4 AWG in 1000 volt and 12, 14 and 16 in 3000 volt rating. Also in shielded constructions.

The large cable is Rockbestos A.V.C. Motor Lead Cable. Made in sizes 18 AWG to 1,000 M C M it has a maximum operating temperature of 230° F.

Many manufacturers have had "pretty good luck" with ordinary wires, but in most such cases the names of their products are not too important in the minds of consumers.

The goods-hungry buyer takes a chance on getting "as advertised" performance from the product he buys, and the sell-or-bust maker *hopes* that he will. Manufacturers of honor-branded products, on the other hand, cannot afford to take this chance.

They must choose their wire carefully — *be certain* that it will not bake out, crack or flow under high operating or ambient temperatures — that it will resist oil, grease, oxidation, fumes and moisture — that it is built to last for the life of the product.

The choice of manufacturers who are building for the future is Rockbestos — the wire that is *permanently insulated* with impregnated felted asbestos. And there are 125 different standard constructions to meet almost every electrical manufacturing requirement.

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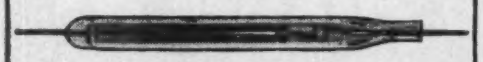

Actual size

Victoreen hi-megohm resistors are specially designed for the hard applications where stability with long life is required. Designed for laboratory use and fine instrumentation. Vacuum sealed in glass to cover a range of 100 to 10,000,000 megohms.

Write for technical data booklet on tubes and resistors.

THE VICTOREEN INSTRUMENT CO.
3800 PERKINS AVENUE
CLEVELAND 14, OHIO

leaflet covers the new passenger car antenna.

Insulator Properties. American Lava Corp., Chattanooga 5, Tenn. Bulletin 245 describes AlSiMag electronic tube insulators and includes a table of mechanical and electrical properties of Steatite, Alumina, and Lava.

Oil Capacitors. The Capacitron Co., 849 North Kedzie Ave., Chicago 51, Ill. Type EC, CC, and BC oil-filled capacitors are high-voltage, high-capacitance units for power supply filtering and similar use. They are described in Bulletins 104 and 105.

Laboratory Apparatus. Boonton Radio Corp., Boonton, N. J. Catalog D contains information on Q meters, QX checkers, generators, accessories, and parts. A price sheet and ordering information are included in the 36-page catalog.

Wire Recorder. Radiotechnic Laboratory, 1328 Sherman Ave., Evanston, Ill. A two-pager covers their new wire recorder complete with built-in loudspeaker, timer, volume level indicator, and microphone with plug and cord.

Industrial Tubes. Westinghouse Electric Corp., Bloomfield, N. J. Industrial electronic tubes have been presented in families according to function in a readable 16-page pamphlet recently issued. The treatment of the subject and the display of information should prove helpful, particularly to industrial engineers who are not electronics experts. Ask for Catalog 86-020.

Relays. Allied Control Co., Inc., 2 East End Ave., New York 21, N. Y. Complete engineering and ordering information is given in the 14 looseleaf pages of a folder issued recently on the line of a-c and d-c relays now available.

Crystal Accessories. Crystal Products Co., 1519 McGee St., Kansas City, Mo., has recently mailed out a 4-page list of crystals, holders, and ovens. A multiple holder is fea-

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When you require plastic parts fabricated to close tolerances, you can always depend on Sillcocks-Miller.

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This know-how saves you time, trouble and money. That's why "it costs you *less* to pay a little more for Sillcocks-Miller quality."

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THE PROBLEM:

How to simplify modern electronic instruments ---get better control with fewer control units?

Cutaway view of the Helipot

THE ANSWER:

THE BECKMAN Helipot

(trademark of the HELIcal POTentiometer)

– almost 12 Times* the Resistance Control in Same Panel Space as Conventional Potentiometers!

ON PRODUCT after product the story is the same – the Helipot is revolutionizing potentiometer applications, simplifying control operations, and even making possible advanced electronic instruments impractical with other types of potentiometers. Widely used on precision electronic instruments during the war, the Helipot is an entirely *new* type of potentiometer which every electronic manufacturer and user should investigate.

Briefly, here's the Helipot principle . . . whereas a conventional potentiometer consists of a *single* coil of resistance winding approximately 4" long, the Helipot has a potentiometer wire approximately 46"* long coiled *helically* into a case which requires *no more panel space* than the conventional unit. By means of a simple guide, the slider contact follows the helical path of the resistance winding from end to end as a single knob is rotated. Result . . . almost *twelve* times the amount of control – far greater accuracy, finer settings, greater range – *at no increase in panel space requirements!*

Let us study your potentiometer applications and suggest how the Helipot can be used – possibly already is *being* used by others in your industry – to simplify control operations, get greater accuracy and range, and increase the utility of modern electronic equipment. No obligation, of course. Write today outlining your problems.

HIGH LINEARITY—as a result of fulfilling large wartime requirements for ultra-precision circuit controls, Helipots are mass-produced with linearity tolerances of one tenth of one percent—and even less!

WIDE RANGE—By coiling a long potentiometer slide wire into a helix, the Helipot provides many times the range possible with a single turn unit of comparable diameter and panel space.

PRECISE SETTINGS—Because of the many-times-longer slide wire, settings can be made with an accuracy impossible with single turn units.

LOW TORQUE—Of special interest for power-driven applications—the Helipot has unusually low torque characteristics. The 1½" Helipot, for example, is available with a torque of only 1 inch/ounce.

***HELIPOTS ARE AVAILABLE IN 3 STANDARD SIZES:**

TYPE A—5 watts, incorporating 10 helical turns and a slide wire length of 46 inches, case diameter 1¾", is available with resistance values from 25 ohms to 30,000 ohms.

TYPE B—10 watts, with 15 helical turns and 140" slide wire, case diameter 3¼", is available with resistance values from 100 ohms to 100,000 ohms.

TYPE C—2 watts, with 3 helical turns and 13½" slide wire, case diameter 1¾", available in resistances from 5 ohms to 10,000 ohms.

The Type B is also available in special sizes of 25 and 40 helical turns, with resistances ranging from 500 ohms to 300,000 ohms, and containing more than 100,000 change-of-resistance steps.

*Data above are for the standard Type A unit.

Send for the New Helipot Booklet!

THE Helipot CORPORATION, 1011 MISSION STREET, SOUTH PASADENA 2, CALIFORNIA

Skilled Technicians

OF BY FOR RADIO

OUR young men come to us from every walk of life—from the farm—from the city—rich and poor—many ex-GI's. They represent every race and creed but they do have ONE thing in common.

They're all men *OF* Radio, *BY* Radio and *FOR* Radio. They've grown up with a "cat's whisker" and a set of headphones as playthings. The only lullabyes they remember are the ones they heard over Dad's Battery Set, with all the knobs, dials, and switches, when radio itself was an infant.

These young men have never known a world without radio, and they never want to. Radio has molded their minds, provided them with an absorbing hobby and given them the means of earning a good living.

SKILLED MEN FOR RADIO

Now, with their training at National Schools behind them, they are prepared to contribute their skill, talent and creative ideas to an industry which is literally a part of them.

We feel fortunate indeed to have had the privilege of awakening the dormant abilities of many men now holding prominent positions in Broadcasting, Communications, Radio Sales and Service, Television and Electronics. And we look forward with pleasure to an ever-broadening educational program, designed to train still more men to fill the thousands of specialized positions radio will require in the future.

During the four decades since we first began to build men for Industry, we have kept accurate student records and compiled unusually complete performance charts. Thus we have acquired a keen insight into the most effective ways to inspire radio-minded men to APPLY their training, and to use their creative abilities to the best advantage of themselves and their employers.

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You'll be impressed by our methods and observations, as they apply to YOUR personnel problems. You'll welcome an opportunity to learn how we inspire our students to ACTION, how we develop in them those vital traits of character which make them an asset to any employer.

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tured for four different crystals, any one of which can be selected by a rotary switch.

Thyratrons and Rectifiers. Chatham Electronics, 475 Washington St., Newark 2, N. J. Data sheets on 13 rectifier and thyratron tubes are loose-leaf bound into a paper cover. Characteristics, tube base connections, and maximum ratings are given for the industrial electronic tubes.

Crystals. Reeves-Hoffman Corp., 215 East 91st St., New York 28, N. Y. Various crystal units are pictured in a 4-page leaflet. Among the more unusual items are a postage-stamp unit less than an inch square and 3/16 inch thick, and a low-cost crystal designed for use in home broadcast receivers to insure foolproof pushbutton tuning.

Nylon Pickup. Astatic Corp., Conneaut, Ohio. The new Nylon 1-J crystal pickup cartridge is glowingly described in a 4-page brochure. Both chuck and needle are formed from Nylon, but the needle tip is sapphire. A special guard protects the unit from damage by careless handling.

Transformers and Reactors. Red Arrow Electric Corp., 100 Coit St., Irvington 11, N. J. A few sample units manufactured by the company are pictured in a 4-page leaflet that describes the types of transformers and engineering services available on order.

Deflection Yokes. The Telectron Co., 1988 East 59th St., Cleveland 3, Ohio. Magnetic deflection yokes and blocking oscillator transformers are described on a single-sheet bulletin. These television components can be used for replacement service of new equipment, owing to their standard method of construction.

Cathode Ray Manual. Allen B. Du Mont Laboratories, Inc., 2 Main Ave., Passaic, N. J. The Operating and Maintenance Manual for the type 274 oscillograph contains so much general information on the use of this and similar equipment

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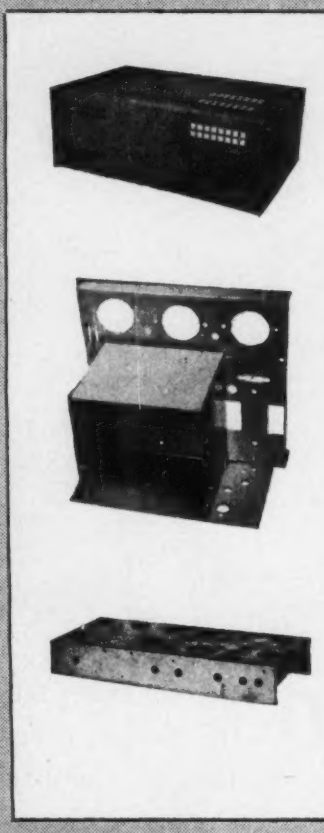

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in the servicing of a-m and f-m equipment that it has been decided to make the 39-page manual available at a cost of 50¢ a copy; less in lots.

Miniature Tubes. Raytheon Mfg. Co., 60 E. 42nd St., New York 17, N. Y. Descriptive data and characteristics have been released on two miniature cathode-type r-f amplifier tubes 6BD6 and 12BD6 that have been designed to replace older tubes like the 6D6 and 6K7.

Noise Suppressor. Technology Instrument Corp., 1058 Main St., Waltham 54, Mass. The dynamic noise suppressor type 910-A, is completely described for prospective purchasers in a 7-page booklet recently made available.

Communications Equipment. Fred M. Link, 125 West 17th St., New York 11, N. Y. An illustrated file folder containing a leaflet serves to bring us up to date on mobile f-m communications equipment, main stations, antennas, and other necessary paraphernalia manufactured by this company.

House Organ. Bodine Electric Co., 2250 W. Ohio St., Chicago 12, Ill. The Motorgram is published by this manufacturer of fractional horsepower motors, and will be of interest to engineers engaged in electronic work involving motors.

Wave Guide Fittings. De Mornay-Budd, Inc., 475 Grand Concourse, New York 51, N. Y. An 18-page profusely illustrated catalog of standard microwave components has just been released. Mechanical and electrical characteristics, including drawings, are presented for each element.

Ballast Bulletin. JFD Mfg. Co., 4117 Fort Hamilton Parkway, Brooklyn 19, N. Y. A new 4-page bulletin has been announced for free distribution listing a complete line of ballast resistors for a-c and d-c receivers.

F-M Brochure. Radio Engineering Laboratories, Inc., 35-54 Thirty-

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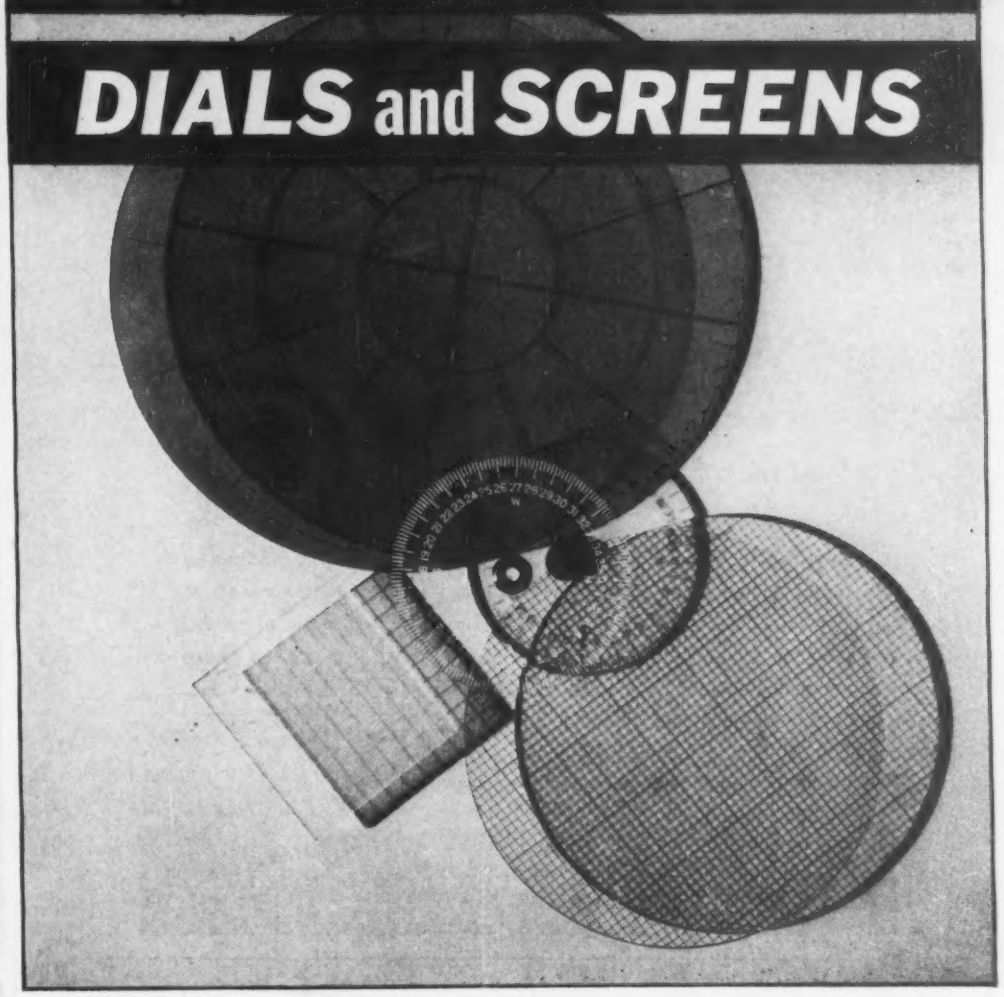

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Sixth St., Long Island City 1, N. Y. Bulletin 5015 details the facilities, accomplishments, and aims of this pioneer manufacturer of f-m equipment.

Wire Wound Resistors. International Resistance Co., 401 North Broad St., Philadelphia 8, Pa. Type FRW flat wire wound resistors have a higher space-power ratio than standard tubular wire wounds and they lend themselves to assembly in stacks and gangs. Write for the 4-page descriptive bulletin.

Chemical Wire Stripper. Division Lead Co., 836 W. Kinzie St. Chicago 22, Ill. Cold removal of Formex or Formvar, and all baked insulations can be accomplished by chemical means using Divco solvents. Technical bulletins outline the process. Other pages describe the company's rosin-core solder and rosin flux remover.

Cable Bulletins. General Electric Co., Schenectady 5, N. Y. Flamenol is the title of a 16-page, four-color bulletin (GEA-4352) that tells the story of manufacture and use of this particular type of conductor. Flamenol Mine-Telephone Cable is described in a companion two-page bulletin, GEA-3612B.

Voltage Controls. Superior Electric Co., 713 Laurel St., Bristol, Conn. Bulletin 150 replaces all other bulletins and describes the complete Superior line of powerstats, automatic voltage regulators, and remote positioners.

Microphones. Electro-Voice, Inc., Buchanan, Mich. Bulletin No. 131 describes the Cardyne cardioid dynamic microphone and Catalog No. 101 presents the complete line of the company's products. An interesting feature of the 19-page catalog is an index identifying microphone types by application so that selection of the proper unit is facilitated.

Time Switches. Automatic Temperature Control Co., Inc., 34 East Logan St., Philadelphia 44, Pa. Two pages of a 4-page leaflet are devoted

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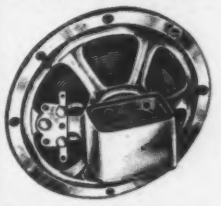

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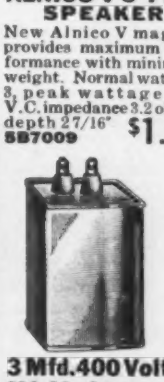
This convenient DETECTOR SET is a highly sensitive, portable instrument for the detection of buried metallic and nonmetallic objects. Detection is possible up to depths of 5 inches. The Detector uses a UHF transmitter operating in the 280 to 380 MC frequency range. The presence of buried objects in the antenna field changes the radiation resistance of the antenna which changes the oscillator loading. These changes are both visual and audible by means of a meter & a speaker or headset. Buried pipes, stones, three roots, air or water pockets, etc., are easily detected. Nails, bullets, decay, fissures, etc., are accurately located in timbers and logs. The Detector Set consists of: a detector head with antenna, reflector, and explorer rod; amplifier and waterproof canvas carrying bag; speaker; headset; spare parts; instructions; and carrying case. Easy to operate. Light weight. Long battery life.
5B9541 (Less Batteries) Your Cost $16.50
C19842 "A" Battery (1 Req) Ea. . 41c
C20616 "B" Battery (3 Req) Ea. $1.51



3 Mfd. 400 Volt Hi-Voltage Condenser
Large 3 mfd., 4000 v. DC. condenser, hermetically sealed in an aluminum can. Size 4½ x 3 11/16 x 7¾" high. **5B3166** $4.95

Supreme Model 543B 1000 O.P.V. A Sensitive Meter
Has pin jack terminals, and includes the following ranges:— 0/6/60/600 D. C. M. A., 0/15/150/600/3000 V. A. C. and D. C., 0/2000/200,000 ohms. This meter is convenient to carry. Weighs 28 ozs. Uses full size 3" meter with a rugged, accurate I. M. A. movement. All resistance ranges are operated by batteries furnished with the unit. Bakelite case. Size: 5 7/8" x 2 1/16" x 2 1/8". Shpg. wt. 2 lbs. **C21745** $18.57

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2½-inch flange mtg. Black dull finish case — Mtg. Hdwe. incl. Either **5B4122**—**0-20 M.A.D.C.** or **5B4116**—**0-300 M.A.D.C.** Special . . $3.23

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Composed of alligator side wrench — 6" insulated driver — metal nib, 5/16" and ¼" nut wrench, ¼" ins. square nut wrench, ¼" hex metal side wrench, 2½" ins. driver with metal nib, ¼" hex slotted insulated wrench driver, 5/16" hex ins. nut wrench, 5" and 6" ins. driver. **5B6547** . . . $2.49

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Contains 7 strands—4 copper—3 of monel. 100 foot coils. **5B5133** . . . . Each 29¢

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Mountings are available in many styles to meet all installation conditions.

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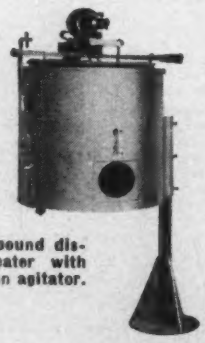

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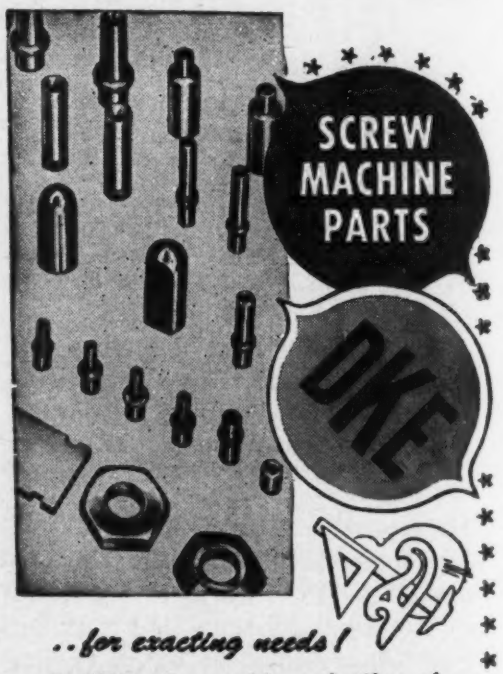

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27 WRIGHT ST., NEWARK, N. J.

to six practical examples of time-switch usage in industry. The various units are illustrated.

Control Devices. Ward Leonard Electric Co., Mount Vernon, N. Y. Bulletin 100,000 just issued is available without charge. It describes all manner of electric control devices such as midget relays, rheostats, time delays, and starters.

D-C V-T Voltmeter. Development Engineering Co., 1818 Ashland St., Houston, Texas. A catalog sheet has just been issued on the model SD-14 d-c vacuum tube voltmeter. The meter is of particular interest because of its small size and long battery life.

F-M Broadcasters. Federal Telephone and Radio Corp., Newark 1, N. J. Complete with circuit diagrams, specifications, and illustrations, Federal's latest publication on its 1 and 3 kilowatt f-m broadcast transmitters for the 88 to 108 megacycle band has recently been printed.

Communications Receivers. The Hallicrafters Co., Chicago, Ill. Two receivers, model S-38 and S-40, tune from 540 kilocycles to 32 megacycles and 540 kilocycles to 43 megacycles respectively in four bands. The SX-42 gives continuous coverage from 540 kilocycles to 110 megacycles on either a-m or f-m. These receivers and some antennas are described in an 8-page folder.

Television Antenna. Andrew Co., 363 East 75th St., Chicago 19, Ill. A 2-page technical data sheet, complete with graphs, describes the Di-Fan television and f-m broad band antenna.

Small Gears. Gear Specialties, 2635 W. Medill Ave., Chicago, Ill. A request on company stationery will bring a copy of the 4-page catalog bulletin that tells about small gears and their applications.

Snap-Action Switches. Microswitch, Freeport, Ill. Manual safety switches are featured in Data Sheet No. 38, comprising two loose leaf pages printed on both sides.

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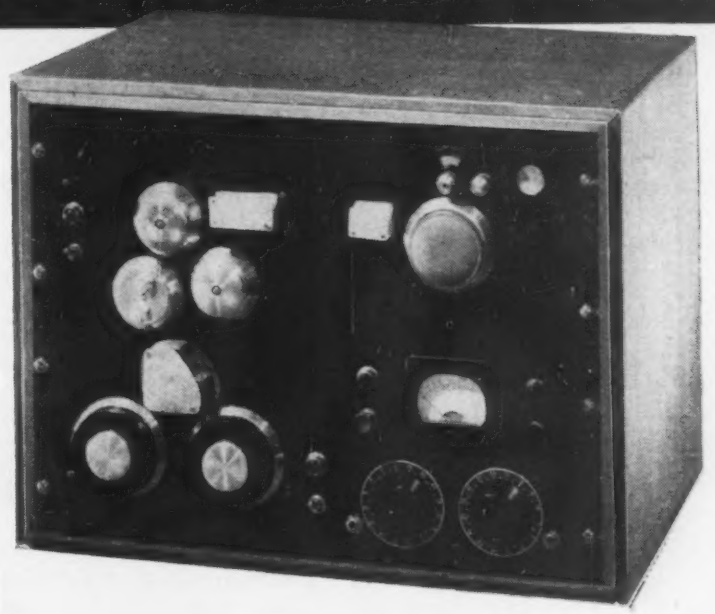
WIRE RECORDER
ACHIEVES HIGH FIDELITY



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MAGNECORDER OFFERS YOU . . . HIGH FIDELITY . . . frequency response flat within 2 db from 50 to 12,000 cps with signal noise ratio of well over 45 db. Less than 1½% harmonic distortion. ELIMINATION OF WOW AND FLUTTER . . . 30 MINUTE PLAYING TIME . . . HIGH SPEED FORWARD-REWIND SPOOL . . . SIMPLE OPERATION . . . LASTING QUALITY . . . GENUINE ECONOMY. Write for literature.

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NEWS OF THE INDUSTRY

Edited by JOHN MARKUS

PICAO considers radar for world airlines; new IRE officers; television fanfare; review of OSRD history – "Scientists Against Time"

National Electronics Conference is Well Attended

THIS YEAR'S National Electronics Conference at the Edgewater Beach Hotel, Chicago, Oct. 3-5, drew an attendance of approximately twenty-five hundred for the sessions and exhibits. A total of 65 technical papers were presented, along with demonstrations which included the infrared sniperscope.

The papers presented at the Conference will be published in the "Proceedings of the 1946 National Electronics Conference", priced at $3.50. Orders should be sent to E. H. Schulz, Secretary, National Electronics Conference, Technology Center, Chicago 16, Illinois. Some copies of the 1944 "Proceedings" may still be available at $3.00 each. No show was held in 1945, due to wartime travel restrictions.

Officers for 1946 National Electronics Conference. Rear, left to right: C. A. Emery of Westinghouse, vice-president; Louis T. Rader of Illinois Institute of Technology, vice-president; A. B. Bronwell of Northwestern University, executive vice-president. Seated, left to right: J. E. Hobson of Armour Research Foundation, chairman of board of directors; E. H. Schulz of IIT, secretary; W. O. Swinyard of Hazeltine, president; R. E. Beam of Northwestern University, vice-president

U. S. Demonstrates Radio Aids to Air Navigation

IN RESPONSE to a suggestion by the Provisional International Civil Aviation Organization (PICAO), the British, U. S., and Australian governments have presented demonstrations of the various air navigation and communications systems now used or in process of development. The British demonstrations were conducted in and about London for PICAO delegates from Sept. 9th to 30th, after which the group was flown to New York for demonstrations at LaGuardia Airport and the CAA overseas communications center at Sayville, Long Island Oct. 7 and 8, thence to Indianapolis for a carefully planned series of lectures, demonstrations, and exhibits from Oct. 10 through the 23rd. Army planes flew the worldwide group of delegates back to New York City for an inspection of Airborne Instrument Laboratories and demonstrations of loran Oct. 25-26, after which the official delegates comprising the Special Radio Technical Division of the PICAO Air Navigation Committee convened in Montreal, Canada Oct. 30 to determine which systems will be specified for international adoption.

Navigation equipment demonstrated on the U. S. program as

Bendix airport surveillance system, employing high-definition search radar as an auxiliary to GCA and an aid to traffic control. Center frequency is 2,880 mc, and antenna rotation rate is 30 rpm. This equipment was demonstrated to PICAO delegates at Indianapolis

being now in use or ready for use falls into four categories: (1) long-range navigation, for overseas flights and long land flights as over the North Pole—loran and low-frequency omnidirectional range; (2) short-range navigation, as between airports of a given country or short over-water flights—vhf omnidirectional range, distance-measuring equipment, radio compass, automatic direction finder, pulse alti-

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UHF PRECISION INSTRUMENTS

HARMONIC FREQUENCY GENERATOR

PROVIDES harmonic output voltages in 10 or 40 mc series with crystal-controlled accuracy.

SELECTS 10 or 40 megacycles series by means of front panel switch.

USED FOR calibration of receivers, wavemeters, or (with Beat Detector built into instrument) for calibration of oscillators and signal generators. May also be used in conjunction with a low-frequency communications-type receiver to determine UHF oscillator drift. A mixer unit is available for this application.

PRECISION FREQUENCY METER

Completely portable Accuracy 0.1% Models available from 100 to 2000 megacycles with 2 to 1 frequency coverage on each model.

RECOMMENDED FOR:

- Production testing
- Measurement of oscillator drift
- Independent alignment of transmitters and receivers
- Precise measurements of frequencies

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Specialists in the Development and Manufacture of UHF Equipment

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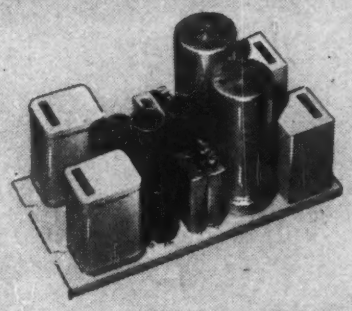
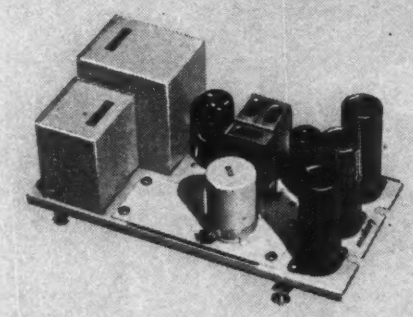
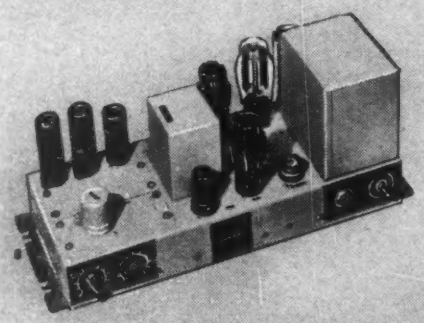
Broadcast Audio Facilities



...featuring the Langevin Type 111-A, *Dual* Preliminary Amplifier; gain 47 DB; output level +16 DBM; input impedance 30/250/600 ohms; output impedance 600 ohms. This amplifier can be used also as a booster . .



...in addition, the Langevin Type 102-A Program Amplifier is *available from stock;* gain 55 DB; output level +28 DBM; input impedance 30/250/600 ohms; output impedance 600 ohms. This unit has provisions for decreasing the gain to 45 or 35 DB . . .



...in order to provide for the broadcaster's monitoring facilities, Langevin is *ready to ship* the Type 108-A Amplifier; gain 43 or 63 DB; output level +43 DBM (20 watts); input impedance 600/25,000 ohms; output impedance 8/500 ohms . . .

...also available for immediate shipment are the Langevin Type 201-B Rectifier and Type 114-A AC, DC Monitor Amplifier, a 4 watt unit.

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SOUND REINFORCEMENT and REPRODUCTION ENGINEERING

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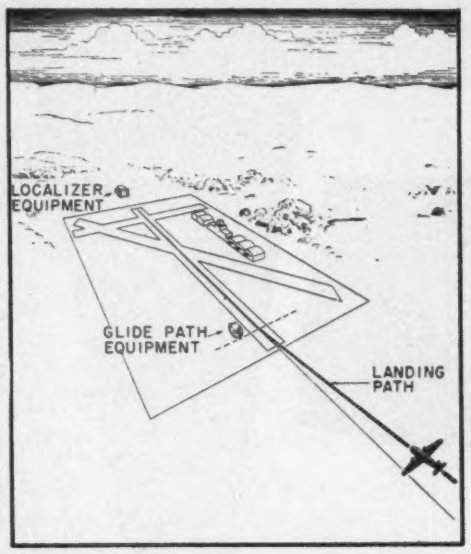
meter; (3) instrument approach and landing during conditions of poor visibility or low ceiling—CAA instrument landing system, ground-controlled approach, and microwave instrument landing system; (4) air traffic control at airports, to convert random arrivals into orderly landings with minimum delay under all weather conditions—search radar, vertical separation indicator, and



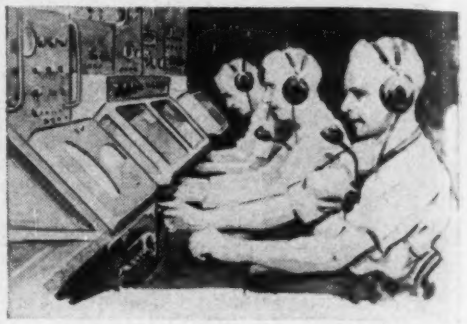
Perspective of typical airport, showing locations of the two units employed in Sperry microwave landing system

air traffic control system. A fifth category, covering complete navigation systems or individual equipments intended for future use, was also given consideration. Details of some of the systems follow.

The low-frequency omnidirectional range provides continuous indication of azimuth without ambiguity through 360 degrees about a transmitting station operating in the 50-400 kc band, and employs a 300-cycle subcarrier for production of the f-m component whose phase is a function of azimuth. One 400-watt station is in operation at Indianapolis, and several 10-kw stations will be in operation in U. S. coastal regions by July 1, 1947.

Loran is a pulsed type of radio transmission in the band 1,800 to 2,000 kc, providing pinpoint navigation data over reliable ranges of 700 nautical miles by day and 1,400 by night. Accuracy of range determination from the baseline joining two loran transmitters is better than 1 percent. The U. S. government is now operating 35 transmitting stations throughout the world, with four more ready for use if needed, and 9 others are being operated by Great Britain and Canada, all on a 24-hour schedule. The RCA AVR-26 airborne loran receiver weighs approximately 35 lb.

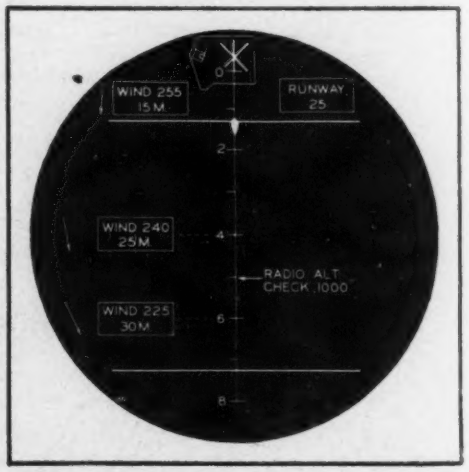
The CAA vhf omnidirectional range operates in the 112-118-mc band for short-range navigation,



In GCA three operators seated before scopes on the ground observe the position of an incoming aircraft with respect to glide path and azimuth markings on the screen, and bring the pilot down to contact with the runway through fog entirely by radioed voice instructions

using a 10-kc subcarrier. A number of stations have already been established on the Chicago-New York route.

Radio pulse distance-measuring equipment was demonstrated by CAA, Hazeltine Electronics Corp., and Federal Telecommunication Laboratories, Inc. Operation is on 1,000 mc. Use with omnidirectional ranges gives the pilot of an aircraft a continuous indication of distance and direction from a range. Only experimental models are now in use. A transmitter in the aircraft sends a continuous flow of r-f pulses



In RCA's proposed Teleran system, a picture like this might be sent to the pilot by television during final approach. His aircraft is a spot moving on a map (between 0 and 2). Any other planes within area of map would also show

to the ground beacon, which retransmits similar pulses in reply. The time between transmission of a pulse by the aircraft and recep-

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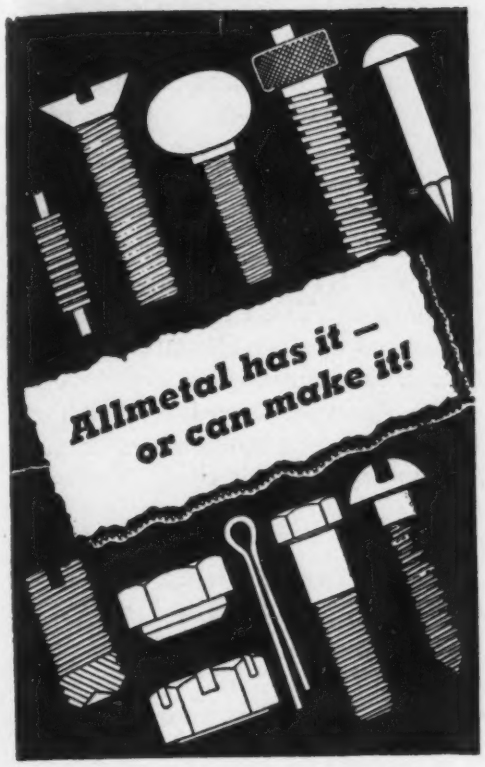

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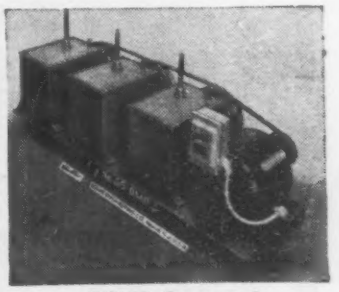
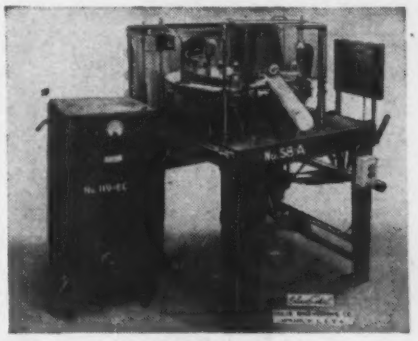
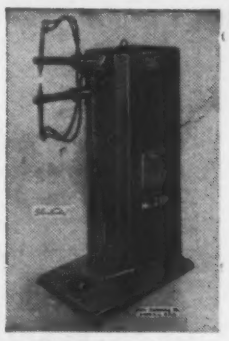


EISLER Compound Vacuum Pump.



24 Head Radio Tube Exhausting Machine.



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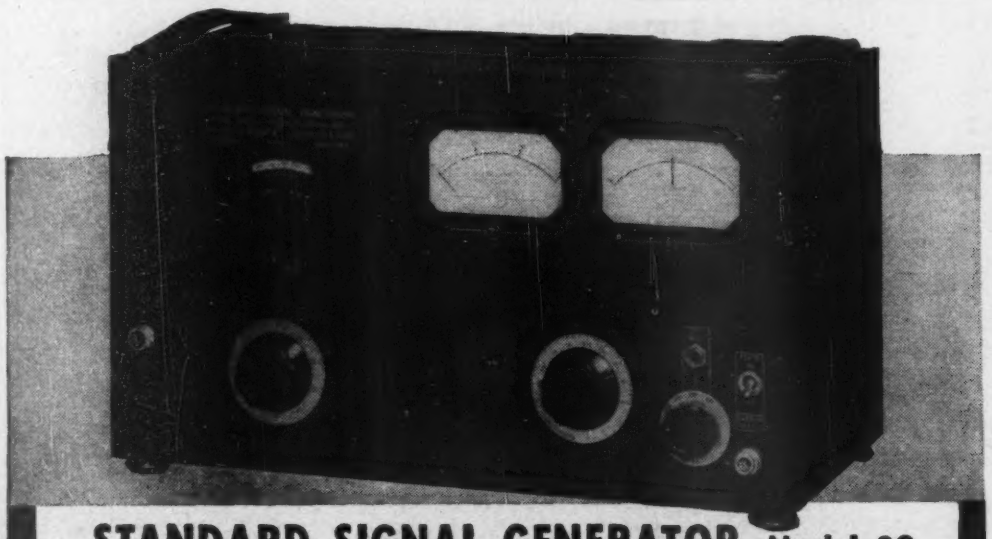

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DIMENSIONS: Width 19", Height 10¾", Depth 9½".

WEIGHT: Approximately 35 lbs.
Suitable connection cables and matching pads can be supplied on order.

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tion of its reply pulse is measured electrically and indicated to the pilot on a meter calibrated in miles.

The CAA instrument landing system (ILS) consists of a runway localizer in the 108-111 mc band, a glide-path transmitter in the 328.6-335.4 mc band (third harmonic of localizer), and 75-mc marker beacons. Sideband frequencies are 90 and 150 cycles. A variation uses a 10-kc subcarrier that is frequency-modulated at 60 cycles to indicate on-course for the localizer by phase comparison. These ILS systems can be hooked up with the autopilot for automatic approach control.

The Sperry microwave version of ILS operates on 2,650 mc, with 600 and 900 cycle modulation. The system is now in the preproduction stage.

The ground controlled approach system (GCA) presented by CAA is a combination of search and precision scan radar units that permits operators on the ground to talk a plane down by radio. No special equipment is needed in the airplane, but ground equipment is complex and requires three to five operators. The Navy has adopted GCA as standard for all its airfields in this country and overseas, and will man 39 units this winter. A GCA unit will soon be installed at LaGuardia Field for use of commercial aircraft. The Navy has made 65,000 GCA landings, 469 of which were under actual instrument conditions. No plane making its final landing approach under instrument conditions has had an accident while under control of Navy GCA.

Traffic Control at Airports

Use of high-power 10-cm search radar at an airport enables control tower crews to see on a screen the positions of all aircraft within up to 30 miles of the airport, for guidance in directing traffic and monitoring holding patterns of planes waiting to land. A video mapping system permits simultaneous production of maps on the screen, showing runways, obstructions, beacon and marker locations, and airport locations in correct relation to planes in the air. Moving target indication (MTI) may be added to subdue ground clutter in the vicinity of the radar antenna by increas-

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ing the contrast between desired and undesired indications.

The CAA vertical separation indicator for airport traffic control employs an airborne transmitter controlled by an aneroid cell between limits of 148 and 154 mc so that frequency is a linear function of the altitude of the airplane. A panoramic-type receiver-indicator on the ground shows by means of pips on a calibrated scale the altitudes of all planes within range that are equipped with the special transmitters. A similar indicator in the airplane is calibrated between minus 1,500 feet and plus 1,500 feet to show only pips of planes at approximately the same altitude.

In anticipation of traffic heavier than 30 to 40 flights per hour along a route, The Teleregister Corporation of New York City has developed a system of automatic aids for obtaining position reports from planes en route and sending instructions automatically to planes.

Systems for Future Use

Lanac, standing for Laminar Navigation Anti-collision System, is a complete integrated all-weather flying system proposed by Hazeltine Electronics Corp. for future use. It includes navigation, fixed-obstacle avoidance, anticollision by lamina segregation, traffic surveillance by ground observers, and instrument approach. It will operate in the 1,000-mc band, using an airborne challenger and replier and a ground challenger, beacons, and cathode-ray display.

Navar consists essentially of a 1,000-mc distance-measuring equipment (DME) serving simultaneously as a Racon (airborne responder beacon) to assist ground radars. Ground equipment includes an S-band search radar and a 1,000-mc responder for the DME. A complete demonstration by Federal Telecommunication Laboratories is expected early in 1948.

Teleran is a combination of ground radar, airborne transponders, and television transmission from ground to aircraft, proposed by Radio Corporation of America for air navigation, traffic control, collision prevention, instrument landing, talk-down landing, automatic landing, automatic flight, etc. The pilot sees on his television

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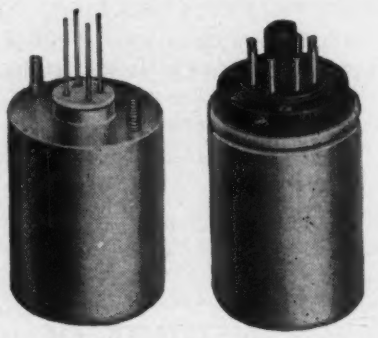

C-5 C-12

Advance hermetically sealed relays maintain their original efficiency under adverse conditions. Dust, moisture, oil or fungus cannot reach precisely adjusted parts. Approved for installation as non-sparking equipment where there is danger from inflammable vapors. Also eliminate failure due to arcing or condensation in low atmospheric pressures. Properly adjusted at the factory, they maintain adjustment in spite of temperature variation, and also are tamper proof.

Model C-5 relay can enclose Series 1500-1600 or Series 6000 (midget telephone type relay). Two mounting screws are provided. All connections solder to terminal wires projecting through the ceramic Steatite insulation disc. Available in models up to 4 pole double throw with either AC or DC coils. Overall size: 1⅝-in. diam. by 2¼-in. high.

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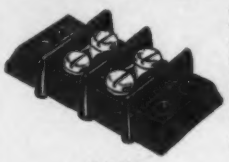
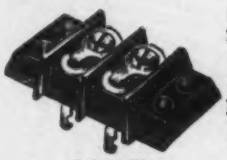


2-142

2-142-¾W



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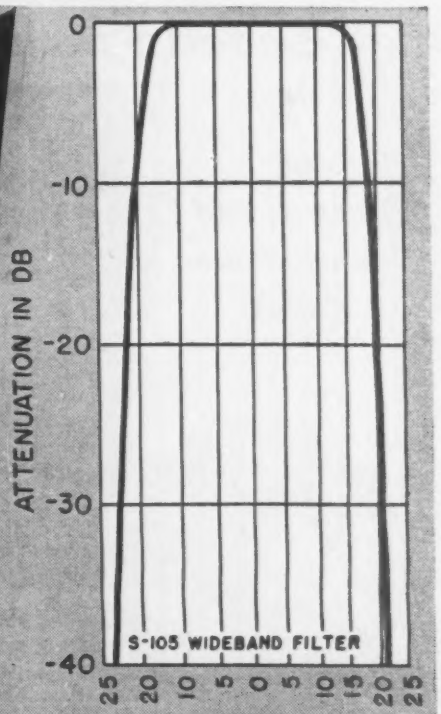

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The customer first approached New England Screw when they became dissatisfied with deliveries and service from another manufacturer. Already far behind in production, they had little hope of catching up, much less of saving any money.

"Our delivery schedules had to be set so high," recalled the president of New England Screw, "they didn't dream we could maintain them. But we did! And saved them 86% in the bargain!"

One of the many special screws made by this firm is shown in the illustration at the left. New England Screw has been making standard and special screws and headed shanks for over 50 years, and their modern manufacturing methods are described in an interesting catalog which will be sent to any company requesting it. Engineers of any manufacturer using screws or headed shanks are invited to consult with their Engineering Department which will gladly co-operate.

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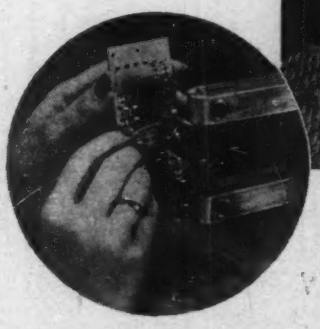
of light gauge non-ferrous metals



This photograph shows a typical assembly operation in a radio parts plant... welding 0.025" dia. nickel plated copper wire to light gauge brass clips mounted on a bakelite panel. Scores of manufacturers of these and other types of delicate non-ferrous metal assemblies are now doing a better job in less time at lower cost... with the RAYTHEON Condenser Weldpower. Changing from slow, costly soldering operations or use of too-large, too-costly bench welders, these users find the RAYTHEON 56 m.f.d. and 200 m.f.d. units are accurate, fast, economical. Write for detailed information. Ask for Bulletin DL-W-507.

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screen only data pertinent to his position and altitude. Flight tests are scheduled for 1947.

Shoran is a short-range navigation system employing a form of radar for accurate positioning of an aircraft. A transmitter in the plane sends out a pulse that triggers two fixed stations, which in turn transmit pulses to a receiver and timer in the plane.

New IRE Officers

NEW PRESIDENT of the Institute of Radio Engineers for 1947 is Dr. W. R. G. Baker, vice-president of General Electric Co. in charge of

W. R. G. Baker, new IRE president

electronics. He will take office shortly after the first of the year, succeeding F. B. Llewellyn of Bell Telephone Laboratories.

The vice-president for 1947 will be Noel Ashbridge, deputy director-general of British Broadcasting Corp., London.

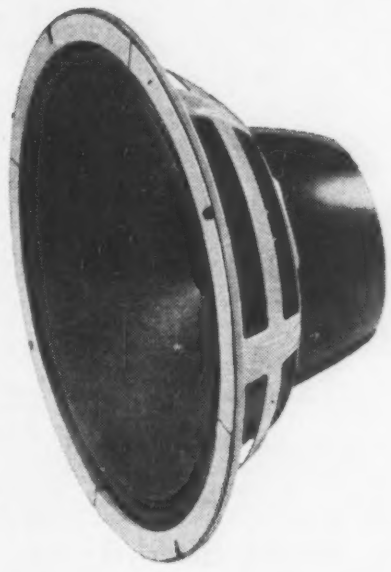
Three new directors were elected to serve for 1947-1949: Murray G. Crosby, consulting engineer with Paul Godley Co., Upper Montclair, N. J.; Raymond F. Guy, radio facilities engineer with National Broadcasting Co., New York; Raymond A. Heising, patent engineer with Bell Telephone Laboratories, New York.

Television Conference

A RECORD CROWD for television, officially recorded as 1,200 for the banquet, attended the Second Tele-

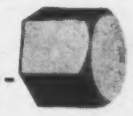
GE SPEAKERS
make the difference

● The finest receiver (from every other design standpoint) can only be as good as the speaker it houses. G-E speakers have been built to make good receivers better. The check list of outstanding features given below will tell the story to your design engineers —the resultant higher quality performance will tell the story to your consumer market.



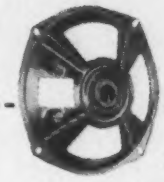
Aluminum Foil Base Voice Coil

Better Tone Quality and Reproduction • Unusually High Wattage Handling Capacity • No Warping of Voice Coil • Unaffected by Humidity and Ambient Temperatures • Free From Ageing Due to Over-Loading Voice Coil.



Alnico V Permanent Magnets

Expands Design Possibilities • Overall Greater Efficiency • Greater Sensitivity • Reduction in the Possibility of Mechanical and Electrical Failures.



All Weld Construction

Better Controlled Airgaps • Increased Efficiency • Rigidity—Strength—Durability.

Consult General Electric now, for your 1947 speaker requirements. Write to: General Electric Company, Electronics Department, E6810, Syracuse 1, N. Y.

GENERAL ELECTRIC

160 E4

vision Conference and Exhibition of the Television Broadcasters Association, held at the Waldorf-Astoria hotel in New York City Oct. 10 and 11. Despite flickering screens, ghost images, unexplained fadeouts, blurred images, and high prices (in relation to screen size and prewar figures) for the few

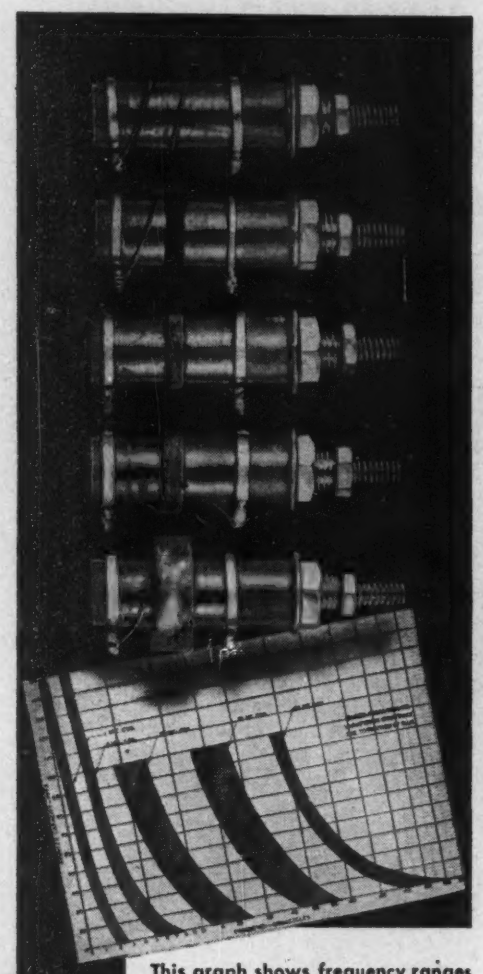
In recognition of their work in developing the image orthicon, Dr. Albert Rose, Dr. Harold Bell Law, and Dr. Paul K. Weimer of RCA Laboratories, Princeton, N. J., were presented with awards at the TBA Second Television Conference and Exhibition. This tube freed television from limitations arising from previous necessity for high-intensity illumination

receiver models shown, many of those who attended are enthusiastically heralding the Conference as the second rebirth of commercial television. Conspicuous by its absence was Columbia Broadcasting System, whose color television system has caused much controversy. An ad saying simply "Compliments of a friend", printed in six colors in the official program booklet, aroused much conjecture.

J. R. Poppele, president of TBA, declared that the Conference and Exhibition will provide conclusive evidence that television is ready to proceed on a greatly expanded commercial basis and that the new industry is well on the way to becoming one of the most important in the nation.

Radio Production Figures

PRODUCTION OF 3,242 television receivers in September highlights that month's production figures as released by RMA. Other figures show a drop from the all-time production record established in August. Total September RMA



This graph shows frequency ranges covered by each unit. Write us for your full-size copy.

Five Standard Slug-Tuned LS3 Coils Cover ½ to 184 mc

For strip amplifier work, the compact (1⅛" high when mounted) LS3 Coil is ideal. Also for Filters, Oscillators, Wave-Traps or any purpose where an adjustable inductance is desired.

Five Standard Windings—1, 5, 10, 30 and 60 megacycle coils cover inductance ranges between 750 and 0.065 microhenries.

CTC LS3 Coils are easy to assemble, one ¼" hole is all you need. Each unit is durably varnished and supplied with required mounting hardware.

SPECIAL COILS

CTC will custom-engineer and produce coils of almost any size and style of winding...to the most particular manufacturer's specifications.

Consult CTC for Three-Way Component Service

Custom Engineering Standardized Designs
Guaranteed Materials and Workmanship

CAMBRIDGE THERMIONIC CORPORATION
437 Concord Avenue, Cambridge 38, Mass.

A major advancement in the recording blank field...

10 Year GUARANTEE

GOULD-MOODY "Black Seal" ALUMINUM RECORDING BLANKS

...at no increase in price!

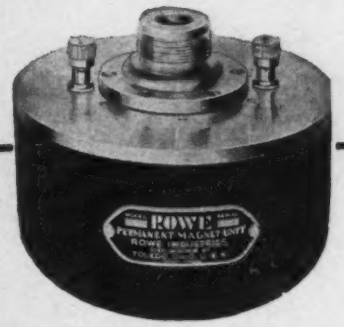
After prolonged research and experimentation, we have introduced technological improvements into "Black Seal" blanks that not only increase life span, but materially enhance the other finer characteristics of these blanks. And so positive are we of the worth of these perfected "Black Seals" that we're offering them to you on an unconditional ten-year guarantee basis.

You can't afford to be a recording isolationist...

"Black Seal" blanks will not rip up, disintegrate or powder after the first playing if kept in storage for any long period of time. You are in no danger of losing valuable recordings in what, up until now, you have considered your safe library of recording blanks. No matter how well you may be satisfied with your present blanks, you can't afford to be a recording isolationist. Try "Black Seals"—if, for any reason whatsoever, you aren't satisfied, return them at our expense.

THE GOULD-MOODY CO.
Recording Blank Division
395 BROADWAY NEW YORK 13, N. Y.

FREEDOM FROM BREAKDOWN



ROWE NO. 7 PERMANENT MAGNETIC DRIVER UNIT

A long lasting unit that provides extra power with a minimum of break-downs and replacements. Overcomes the many annoyances that long have been troublesome to sound engineers.

The 3 lb. 4 oz. ALNICO heavy duty magnet . . . . the one-piece metal diaphragm with voice coil mounted thereon . . . . the heavy gauge steel and brass parts are just a few of the refinements in design and construction. Write for circular 84 which gives complete details.

ELECTRONICS DIVISION

ROWE Industries

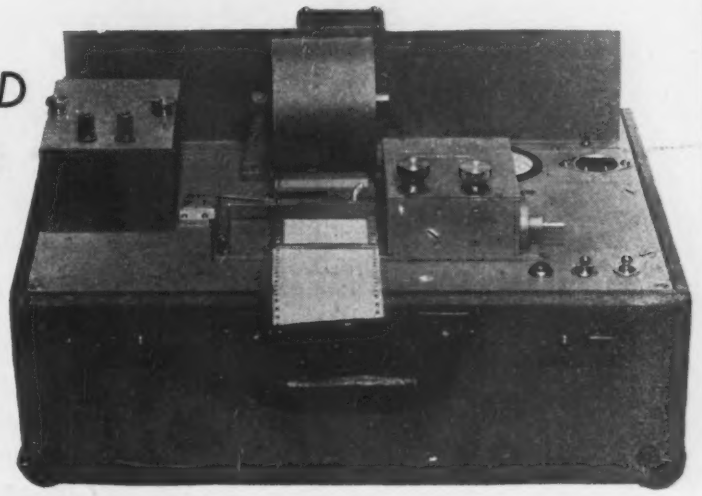
3120 MONROE ST., TOLEDO 6, OHIO

FOR MEASUREMENTS OF

• REVERBERATION TIME • DECAY OF SOUND

• SOUND INTENSITY • LOUDNESS

HIGH SPEED RECORDER MODEL PL with interchangeable input potentiometers



THE GRAPHIC RECORDER FOR THE MODERN ACOUSTICAL ENGINEER

Ask for Literature from the Designers & Manufacturers

SOUND APPARATUS CO.

233 BROADWAY · NEW YORK 7, N. Y.

MORE HEAT PER POUND OF WIRE with KANTHAL RESISTANCE ALLOY*

Kanthal Alloy A-1 allows continuous service temperature of 2462° F. with resistivity of 872 Ohms/C.M.F. at 68° F.

* WIRE, RIBBON OR STRIP

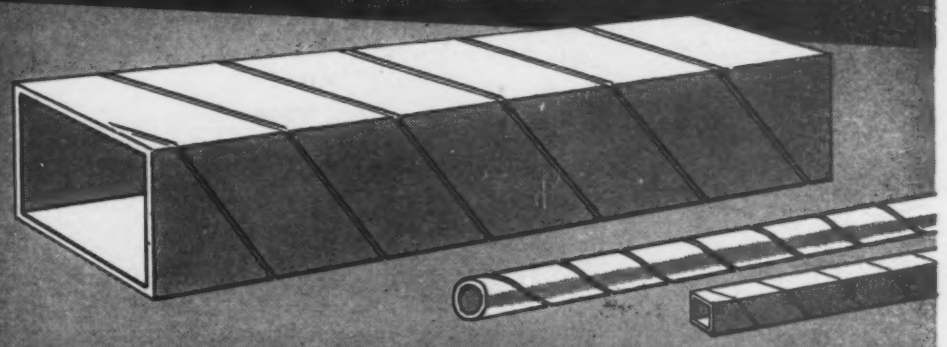
The Kanthal Handbook, comprising 113 pages of complete technical reference material covering all data on the properties, fields of application, and design considerations of the Kanthal alloys, will be sent upon request to engineers writing on company letterheads.

WIRE PRODUCTS SINCE 1880

THE C. O. JELLIFF MFG. CORP.

SOUTHPORT — CONN.

Over 1000 Sizes



PARAMOUNT SPIRAL WOUND PAPER TUBES

SEND FOR ARBOR LIST OF OVER 1000 SIZES

Convenient, helpful listing of over 1000 stock arbors. Includes many odd sizes of square and rectangular tubes. Write for Arbor List today. No obligation.

Square • Rectangular • Triangular
Round and Half-Round

With a wide range of stock arbors . . . plus the specialized ability to engineer special tubes . . . PARAMOUNT can produce the exact shape and size you need for coil forms or other uses. *Hi-Dielectric, Hi-Strength.* Kraft, Fish Paper, Red Rope, or any combination, wound on automatic machines. Tolerances plus or minus .002". Made to your specifications or engineered for YOU.

Inside Perimeters from .592" to 19.0"

PARAMOUNT PAPER TUBE CORP.

616 LAFAYETTE ST., FORT WAYNE 2, IND.

Manufacturers of Paper Tubing for the Electrical Industry

BRADLEY

COPPER OXIDE RECTIFIERS

IDEAL FOR AUTOMATIC CURRENT CONTROL

•

"Coprox" rectifiers may be your answer to more efficient current control. Their varistor characteristics make them ideal for automatic current valving, current limiting, current blocking, as well as current measurement.

Bradley rectifiers are designed to give you trouble-free service. Their electrical characteristics remain stable indefinitely When operated within normal rating, their life is unlimited.

Send for curves showing current, voltage, resistance and temperature characteristics of Bradley copper oxide rectifiers.

Illustrated literature, available on request, shows more models of copper oxide rectifiers, plus a line of selenium rectifiers and photocells. Write for "The Bradley Line."

BRADLEY LABORATORIES, INC.

82 Meadow St. New Haven 10, Conn.

member-company production was 1,323,291 sets, of which 105,344 were radio-phonograph consoles and 17,541 were sets with f-m bands. All but a few of the television sets were direct-viewing video-radio-phonograph combination types. The CPA estimate for September was 1,500,000 sets, as compared to 1,700,000 for August.

Television Station Status

ACCORDING TO an FCC release, as of Sept. 25, 1946 there were 6 licensed television stations rendering broadcast service, 31 outstanding construction permits authorizing new stations, 14 applications designated for hearing and awaiting decision, 11 applications pending disposition of hearings in related cases, 10 applications pending receipt of information requested by the Commission, and 6 applications being processed.

MEETINGS TO COME

DEC. 2-7; NATIONAL POWER SHOW; Grand Central Palace, New York City.

DEC. 5-7; JOINT EMSA AND ASXRED WINTER MEETING; Mellon Institute of Industrial Research and Univ. of Pittsburgh, Pittsburgh, Pa.; sponsored by Electron Microscope Society of American and American Society for X-ray and Electron Diffraction; make dinner reservations with Dr. Max Lauffer, Univ. of Pittsburgh.

JAN. 27-31; ELECTRICAL ENGINEERING EXPOSITION; held concurrently with AIEE winter convention; 71st Regiment Armory, New York City.

MARCH 3-6; IRE WINTER MEETING; Hotel Commodore, New York City, with Radio Engineering Show at 34th Street Armory.

BUSINESS NEWS

STROMBERG-CARLSON Co., Rochester, N. Y., has leased the five-story Mayer block in Erie, Pa. for the manufacture of table model radios and undisclosed new products.

SPECIAL PRODUCTS Co., Silver

NEW!

◀ Interior view showing simplicity of making rigid connections

B&W COAXIAL CABLE CONNECTOR

• Easy to install
• Watertight
• Seals Cable Ends

SERVES AS CENTER INSULATOR ON HALF-WAVE DOUBLET

•

The new B & W CC-50 Connector does an excellent job of providing a waterproof termination for a coaxial line where it joins the center of a half-wave doublet antenna. Made of cast aluminum with steatite insulation and forged steel eyebolt with easy soldering connections. Weighs only 12 ounces. Absolutely watertight. Write for details.

BARKER & WILLIAMSON

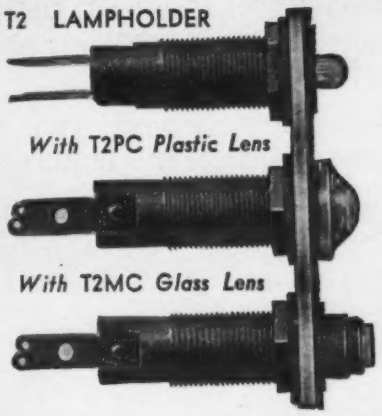
Inductor Coil Headquarters

237 Fairfield Ave., Upper Darby, Pa.

KIRKLAND Pioneer
INDICATING LAMPS

TYPE T2 UNITS

T2 LAMPHOLDER



T2 lampholder, molded of bakelite, holding lip, dia. 11/16". Tip of lamp bulb protrudes sufficiently to be removed from front of panel without use of special tool.

Very low current consumption bulb (0.038 max. amp. on 24 volts). Series resistor of small size on 120-220-440 volts, etc.

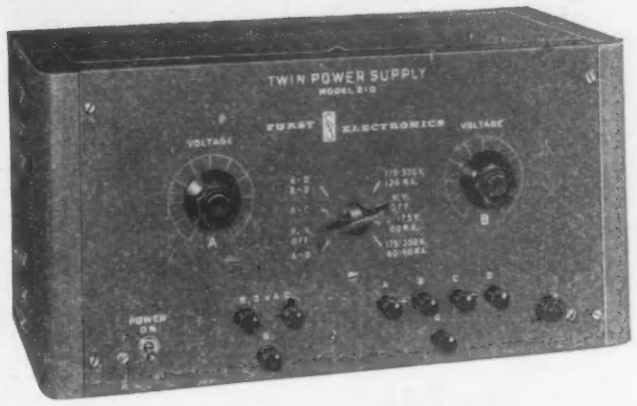
T2PC Lens-cap, molded in plastic.
T2MC Lens-cap, metal with glass lens.

WRITE TODAY FOR CATALOGUE

THE H. R. KIRKLAND COMPANY
8 King Street Morristown, N. J.

TWIN POWER SUPPLY

Electronically Regulated for precise measurements



Two independent sources of continuously variable D.C. are combined in this one convenient unit. Its double utility makes it a most useful instrument for laboratory and test station work. Three power ranges are instantly selected with a rotary switch:

175-350 V. at 0-60 Ma., terminated and controlled independently, may be used to supply 2 separate requirements.
0-175 V. at 0-60 Ma. for single supply.
175-350 V. at 0-120 Ma. for single supply.

In addition, a convenient 6.3 V.A.C. filament source is provided. The normally floating system is properly terminated for external grounding when desired. Adequately protected against overloads.

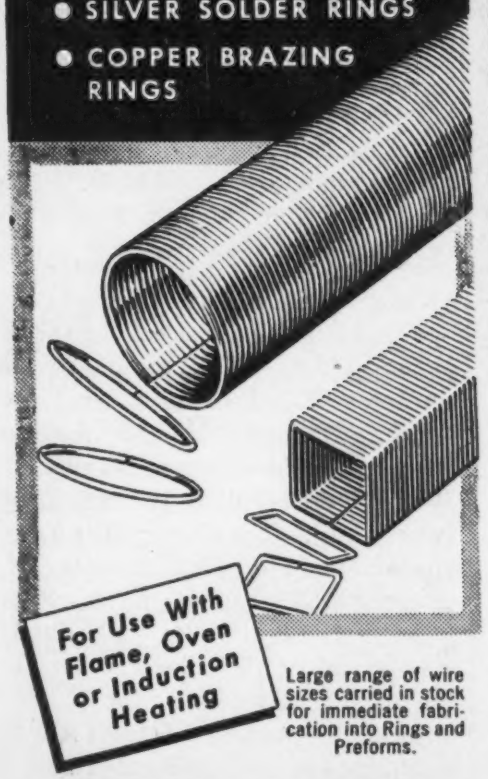
- **Output voltage variation less than 1% with change from 0 to full load.**
- **Output voltage variation less than 1 V. with change from 105 to 125 A.C. Line Voltage.**
- **Output ripple and noise less than .025 V.**

Twin Power Supply Model 210 Complete $115.00 F.O.B. Chicago
Dimensions: 16" x 8" x 8" Shipping Wt. 35 lbs.
(Other types for your special requirements)

FURST ELECTRONICS

800 W. NORTH AVENUE, CHICAGO 22, ILLINOIS

- SOFT SOLDER RINGS AND PREFORMS
- SILVER SOLDER RINGS
- COPPER BRAZING RINGS



For Use With Flame, Oven or Induction Heating

Large range of wire sizes carried in stock for immediate fabrication into Rings and Preforms.

ELECTRONIC SPECIALTIES MANUFACTURING COMPANY
127 North Main Street, Elkhart, Indiana

Align Yourself with

ARCTURUS

—The Oldest Name in Radio Tubes!

Here is your chance to secure those hard-to-get tubes you need. STANDARD ARCTURUS places at your disposal a diversified supply of tubes of every type and description — both War Assets Administration surplus and regular stock. Every tube is subjected to rigid testing and servicing, including packaging.

The supply of some types is limited. To get the STANDARD ARCTURUS monthly announcements of available types of War Assets Administration surplus tubes, clip the coupon below and mail it *at once* with a complete list of your requirements.

FILL IN & MAIL TODAY

ARCTURUS — KNOWN THE WORLD OVER
STANDARD ARCTURUS CORPORATION
NEWARK 4, N. J.
WAR ASSETS ADMINISTRATION AGENCY
Contract No. WAS (p) 146

Standard Arcturus Corp., 101 Sussex Ave., Newark 4, N. J.
Please send me monthly lists of available W.A.A. tubes.

Name .....
Company .....
Address .....
..... E-12

BAER

PHENOL AND VULCANIZED

FIBRE FABRICATIONS

Close tolerances, any quantity—

Volume production and accuracy of BAER phenol and vulcanized fibre parts have resulted in their wide specification for every type of product and equipment. Expanded facilities now make it possible to offer BAER production to manufacturers needing quality parts to exact requirements. Write today for Bulletin 120.

PUNCHED
STAMPED
SHAVED
SAWED
DRILLED
MILLED
TAPPED

N. S. BAER COMPANY

Craftsmen in Fibre Fabrication

7-11 MONTGOMERY ST. • HILLSIDE N. J.

Cryscons

PAT. PENDING

THE DEPENDABLE VARIABLE MICA CAPACITORS

. . . Our CN-351 series are efficient RF trimmer capacitors. Our CN-55 series are dual IF padder capacitors (the latter series may also be had with two fixed series capacitors).

For full details, quotations and deliveries:

CRYSCON, Inc.

UNIONVILLE, CONN.

TELEPHONE — FARMINGTON 599

Subsidiary of

CRYSTAL RESEARCH

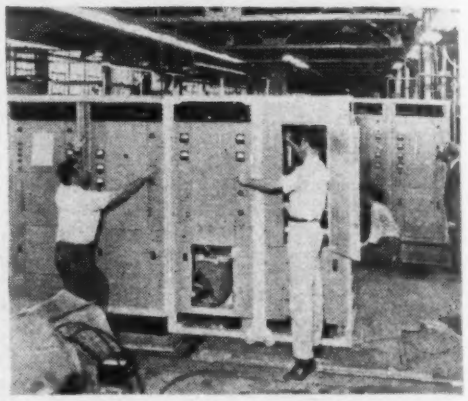
LABORATORIES INC.

29 ALLYN ST., HARTFORD, 3, CONN., PHONE 7-3215

Spring, Md. announces its entry into the industrial photo relay field with units designed and engineered by G. W. Rhein.

ASCO CORP., Cleveland, Ohio, has moved to a new and larger plant at 17702 Waterloo Road.

FEDERAL TELEPHONE AND RADIO CORP. announces it is in full production on both 3-kw and 10-kw f-m transmitters.



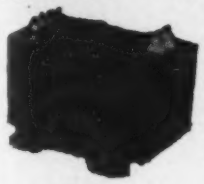
First Federal 10-kw f-m broadcast transmitter undergoing final tests before shipment to radio station WELD in Columbus, Ohio

TRIAD TRANSFORMER MFG. CO., Los Angeles, Calif. has been formed by L. W. Howard and O. D. Perry, and has taken over the inventory and equipment of Electronic Components Co. The new firm will specialize in short orders and special transformers for the electronic field.

CARTER MOTOR CO., Chicago, Ill., is now relocated in its own greatly enlarged quarters at 2644 N. Maplewood Avenue having four times the previous floor area.

NAVY development contracts for guided missiles were held by the following firms as of about Oct. 15: Aerojet Engineering Corp.; Bell Aircraft Corp.; Bendix Aviation Corp.; Camden Eastern Marine Co.; Consolidated-Vultee Aircraft Corp.; Curtiss-Wright Corp.; Electronic Associates, Inc.; Experiments, Inc.; Farnsworth Television & Radio Corp.; General Tire and Rubber Co. of Calif.; Hercules Powder Co.; Merrill Engineering Co.; North American Aviation, Inc.; Radio Corporation of America; Standard Oil Development Co.; Submarine Signal Co.; Sylvania Electric Products, Inc.; United Aircraft Corp.; and Wilmotte Mfg. Co. This list is necessarily imcomplete as contracts

ATTENTION ENGINEERS, TECHNICIANS!



Save on Electronic & Communication Supplies!

Plate Transformer

6200 Volt CT-700 mils, 110V, 60 Cy. Tapped primary 2KVA. Freight charges prepaid to any part of continental USA. Special $39.95.

CW3 Receiver

CW3 Receiver (used for aircraft monitoring) a fixed freq. receiver (1100 KC to 16,500 KC) xtal controlled superhet with BFO and AC power supply; 110V, 60 cy. Coils can be furnished in any of the following groups: 1100-2100 KC; 3500-6100 KC; 5600-10,000 KC; 9400-16,500 KC; complete with add. set of tubes and one set of coils. $32.50 less xtal.

Full Wave Selenium Rectifier

Perfect for bias application—Use your DC relays from an AC source. Only requires 3"x1½" mounting space Rectifier for input up to 300V @ 40 ma. output. $.89 or 5 for $4.00.

Miscellaneous

Type 803 ceramic socket suitable for both 803 & RK 28, etc., tubes—comes complete with rubber and aluminum 5" diameter shock mount. Very special **$1.99**
Socket for 204A, 849.....$1.95
Hour counter, counts up to 9999.9 hours. 110 Volts AC, 60 cy $4.95
9 conductor cable shielded with rubber outside covering .....Per foot $0.12
Coax cable RG8U or RG11U. Per 100 ft. $7.50
Coax couplings for standard .405 cable silver plated chassis or cable.....$0.40
Coax right angle connectors, silver plated $0.90
Chassis feed thru female or both sides....$0.79
6B4 Perfect speech tube.....$1.39
872A JAN tube..$3.50 **866A JAN tube**..$1.39

All tubes new and guaranteed

All our prices F.O.B. our warehouse, New York, N. Y.
Write for our latest Bulletin 12E
IMMEDIATE DELIVERY

NIAGARA RADIO SUPPLY
160 Greenwich St., New York 6, N. Y.
BOwling Green 9-7993

S·S·White MOLDED RESISTORS
The "All-Weather" Resistors

Actual Size
Other types available in the lower values

RESISTOR BULLETIN 4505 GIVES FULL DETAILS...

It shows illustrations of the different types of S. S. White Molded Resistors and gives details about construction, dimensions, etc. A copy, with Price List will be mailed on request. Write for it—today.

- Noiseless in operation
- Strong and durable
- Good performance in all climates

STANDARD RANGE
1000 ohms to 10 megohms
• NOISE TESTED •

At slight additional cost, resistors in the Standard Range are supplied with each resistor noise tested to the following standard: "For the complete audio frequency range, resistor shall have less noise than corresponds to a change of resistance of 1 part in 1,000,000."

HIGH VALUES
15 to 1,000,000 megohms

S.S.WHITE INDUSTRIAL DIVISION
THE S. S. WHITE DENTAL MFG. CO.
DEPT. R, 10 EAST 40th ST., NEW YORK 16, N. Y.
FLEXIBLE SHAFTS • FLEXIBLE SHAFT TOOLS • AIRCRAFT ACCESSORIES
SMALL CUTTING AND GRINDING TOOLS • SPECIAL FORMULA RUBBERS
MOLDED RESISTORS • PLASTIC SPECIALTIES • CONTRACT PLASTICS MOLDING

One of America's AAAA Industrial Enterprises

make better Electronic Products

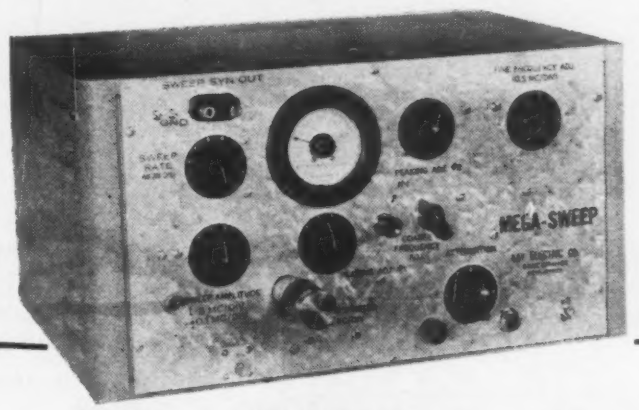
You know the washers are *right* when they are "Quadriga". More than 50 years of production know-how means thorough washer protection. Prompt delivery of any quantity.

Send for Catalog.

ALSO SMALL METAL STAMPINGS

THE QUADRIGA MANUFACTURING CO.
221 A West Grand Ave., Chicago 10, Illinois

Sensational New Sweeping Oscillator!!



Displays Pass Band

Continuous frequency coverage up through the color television bands

The MEGA-SWEEP

The most versatile high frequency oscillator.

These Amazing Features are Found in the MEGA-SWEEP:

- Frequency Range—50 kilocycles to 500 megacycles!
- Sweep Frequency—Up to 40 megacycles!
- Frequency Meter—Measures from 3 to 800 megacycles!
- Continuously Adjustable Attenuator—Band width 1000 megacycles!
- Output—Approximately 0.1 volt at 50 ohms.

The MEGA-SWEEP shows at a glance the response of any network or amplifier. This eliminates the tedious point to point analysis. Its use saves engineering time and stimulates research. Valuable for television production alignment.

The MEGA-SWEEP is priced for wide use in laboratory and production line. $350.00 FOB East Orange.

KAY ELECTRIC COMPANY
47 N. GROVE ST. EAST ORANGE, NEW JERSEY

Mfgs. of The MICRO-PULSER, The TOUCH-TIMER, Micro-Wave components and High-Frequency Wavemeters, and other specialized electronic instruments.

THE IMC ENGINEER IS

On Your Staff

Call him when you need insulation assistance

A quick summons will bring the IMC Engineer to your side with expert advice on your most intricate and stubborn electrical insulation problems. He's ready to . . .

1. Assist in the selection of the best insulating material for each specific job.
2. Give instructions as to proper application.
3. Suggest ways to eliminate waste.
4. Help speed up and increase your production.

He will welcome your call . . . any time. Phone or write to the nearest branch office.

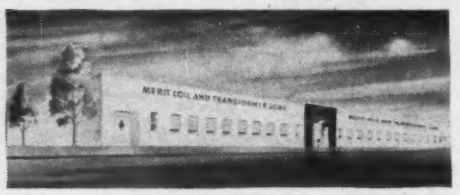
INSULATION
MANUFACTURERS CORPORATION
ELECTRICAL INSULATION

CHICAGO 6, 565 West Washington Blvd.
CLEVELAND 14, 1231 Superior Ave., N. E.

BRANCHES in: MILWAUKEE, 312 East Wisconsin Ave.; DETROIT 2, 11341 Woodward Ave.; MINNEAPOLIS 3, 1208 Harmon Place; PEORIA 5, 101 Heinz Court; and other cities.

are constantly being wound up and new ones entered into. The Army may also be issuing guided missile development contracts, but has not disclosed the type of product involved in its contracts.

MERIT COIL & TRANSFORMER CORP., Chicago, Illinois, has begun work on a new addition that will approximately double the present capacity of the main plant.



Merit Coil & Transformer Corp. plant as it will appear after completion of new addition early in 1947

PERSONNEL

LEWIS W. CHUBB, director of Westinghouse Research Laboratories, was awarded the John Fritz Medal and certificate by four engineering societies—ASCE, AIMME, ASME, and AIEE—"for pioneering genius and notable achievements during a long career devoted to the scientific advancement of the production and utilization of electrical energy".

SAMUEL G. LUTZ has been appointed chairman of the Electrical Engineering Department of the College of Engineering, New York University. In 1940 he was project engineer in charge of speech secrecy systems at Naval Research Laboratory. He directed important countermeasures work for the Navy in 1943, and in December 1944 was made head of the Measurements and Direction Finding Section of NRL.

WALTER B. SCHULTE, founder and president of Micro Switch Corporation, now a division of First Industrial Corporation, Freeport, Illinois, is retiring Dec. 15, and will be succeeded by William W. Gilmore, executive vice-president.

ROBERT M. BENNETT, Jr. has been appointed chief engineer of St. Louis Microphone Co., St. Louis, Mo.

RALPH A. GALBRAITH, contributing author to the MIT staff book,

Better
ATLAS SOUND Equipment
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Double Reentrant. For driver units. 3 and 4 foot air column lengths.

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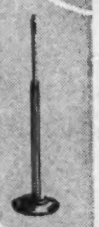

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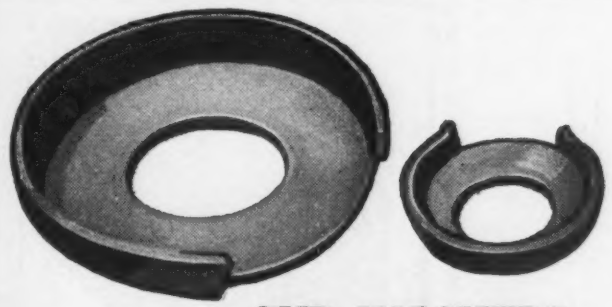

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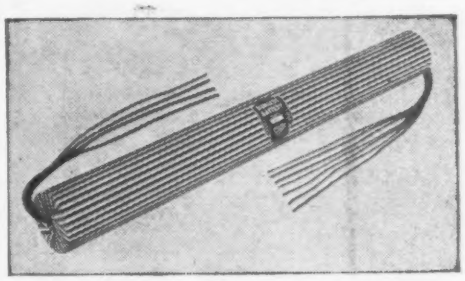

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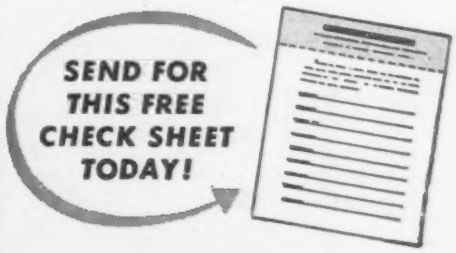

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0-10-50-250-1000
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Size 3x6x2

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THE DEFIANT! $83.95 Complete
25 Watt Sound System, wired, ready to use!

A reliable amplifier with 2 mike and 1 phono inputs, two 12" 20 oz. 13 watt PM speakers with 25' cables, two 12" walnut 7 ply wall baffles; one crystal microphone with table stand and 15' shielded cable.

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RADIO SUPPLY & ENGINEERING CO., Inc.
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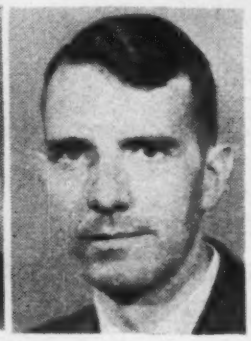
"Principles of Radar", has been appointed professor of electrical engineering and chairman of the department at Syracuse University, Syracuse, N. Y.

RAY C. BIERMAN becomes senior electrical engineer at Webster-Chicago Corp., Chicago, in charge of development work on wire recorders, amplifiers, and other electronic devices. He was formerly chief engineer with Permoflux Corp., Chicago.

R. C. Bierman



H. K. Skramstad

H. K. SKRAMSTAD is now chief of the Guided Missiles Section of the National Bureau of Standards, which developed the radar-guided BAT glide bomb in cooperation with OSRD, MIT, and the Navy Department. Dr. Skramstad played a key part in the development of the BAT, which was the first fully automatic guided missile to be successfully used in combat by any nation.

DALE POLLACK, formerly vice-president in charge of engineering with Templetone Radio Mfg. Corp., announces the opening of his office and laboratory at New London, Conn., specializing in frequency-modulation development and research.

DONALD G. FINK, editor of ELECTRONICS, was on Oct. 30 elected to the board of directors of McGraw-Hill Book Co., New York, N. Y.

ROBERT WILSON, now a professor in the physics department of Harvard University, was elected chairman of the Federation of American Scientists, an organization of 3,000 scientists seeking public understanding and world control of atomic energy under international law. Dr. Wilson was director of the Nuclear Physics Research Division

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PORTABLE WHEATSTONE BRIDGE
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Literature on request

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In addition to the unmounted cells shown here, Bradley also offers cells in a variety of standard mountings, including plug-in and pigtail types.

For direct conversion of light into electric energy, specify Bradley's photocells. They are rugged, lightweight and true-to-rating.

Illustrated literature, available on request, shows more models of Bradley photocells, plus a line of copper oxide and selenium rectifiers. Write for "The Bradley Line."

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Production material checked to assure highest uniform quality of product.

Castings made to customer's special order on the basis of sketches or blue prints furnished.

Information and suggestions furnished on request.

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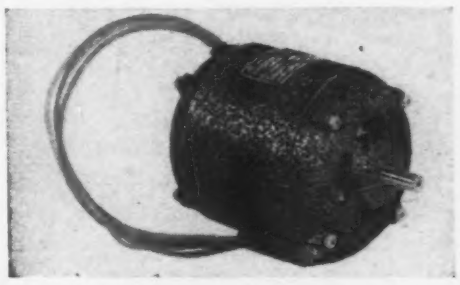
NEW MODEL



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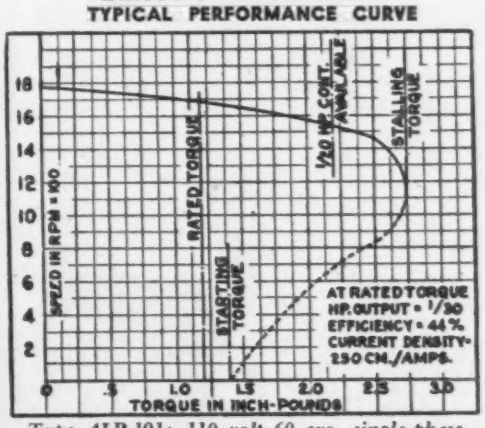
TYPICAL PERFORMANCE CURVE



Type ALP-191; 110 volt 60 cyc. single-phase Capacitor start & run; Motor Capacitor Value 4.25 Mfd. Curve #235.

Elinco ALP Frame Motors are 3⅜" x 4-5/16" capacitor start and run, two and four pole AC motors, internal fan cooled. Continuous duty rating—as induction motor to 1/30 h.p. at 1700 r.p.m.; as synchronous motor to 1/60 h.p. at 1800 r.p.m. Substantially higher ratings are available at speeds of 3400 and 3600 r.p.m. respectively. Also, higher rating for intermittent duty.

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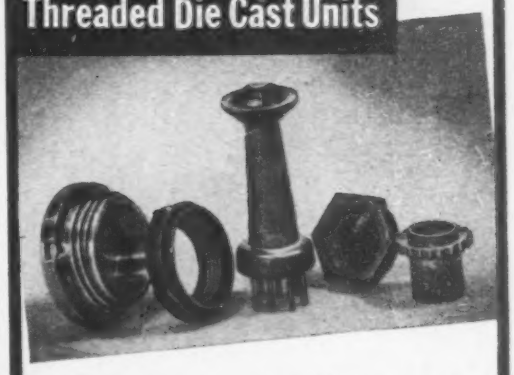

Intricate parts of 100% rust-proof Zinc alloy.
Accurate to specification. Held to tolerances of .005.
Threads require no machining.
Ideal for instrument, small machine and minute electronic parts.

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at the Los Alamos, New Mexico laboratory of the Manhattan District Project.

WILLIAM A. HIGINBOTHAM, past chairman of the Federation of American Scientists, will remain in Washington as executive secretary of the Federation. He worked on radar at MIT Radiation Laboratory early in the war, and was later head of the Electronics Group in the Los Alamos laboratory that developed and tested the first atomic bomb.

LADISLAUS L. MARTON received the appointment as principal physicist in the Electronics Section of the National Bureau of Standards, and will initiate a program of research on basic theory and applications of electron and ion beam devices. He was previously on the faculty staff of Stanford University, where he headed the Division of Electron Optics.

L. L. Marton B. Adler

BEN ADLER has been appointed vice-president in charge of engineering at Transmitter Equipment Mfg. Co., New York City. He was formerly chief facilities engineer at American Broadcasting Co.

CARL W. MULLER has been made vice-president and general manager of Sorensen & Co., Inc., Stamford, Conn. He received the Civilian Meritorious Award for wartime work designing instruments for the Army Air Forces.

WILLIAM N. GREER has moved his offices to San Juan, Porto Rico, where he will continue the practice of general communications engineering.

ALCIDE PROSDOCIMI has been elected vice-president in charge of the International Division of Solar Mfg. Corp., New York City.

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Use current efficiently.
Low operating cost.
Mechanics prefer Vulcans because they have the "hang" or balance a skilled workman likes.
Screw tip for high efficiency.
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The VULCAN Pygmy is particularly useful for delicate jobs in cramped space.

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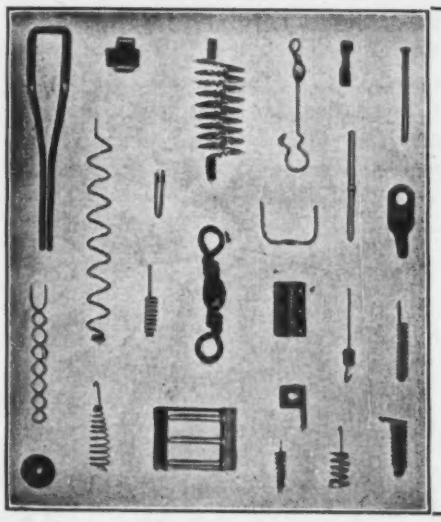

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Filaments, anodes, supports, springs, etc. for electronic tubes. Small wire and flat metal formed parts to your prints for your assemblies. Double pointed pins. Wire straightened and cut diameter up to ⅛-inch. Any length up to 12 feet.

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COAXIAL RESISTOR

A Wide Band Line Termination with Exceedingly low VSWR Characteristics.

The Model 81 Termaline is designed to serve as a matched load which dissipates all power applied to it. Featuring very low VSWR's, the Termaline is very useful in measurement work at VHF-UHF-SHF.

Frequency—Zero (d-c) to 4000 mc. • *Input Impedance*—51.5 ohms • *Power Capacity*—50 watts continuous, higher powers for short periods • *Fittings*—AN Type UG-23 female coupling for RG-8, 9 and equivalent • *Physical Dimensions*—(Overall) 9⅜" L x 5" H x 2⅝" W. • *Finish*—Platinum gray with chrome trim. Collapsible handle.

APPLICATION

1. As an impedance standard for accuracy and repeatability in VHF-UHF-SHF measurements.
2. General use as a non-reactive termination for r-f lines.
3. As a dummy load while tuning up transmitters.
4. In conjunction with the slotted line for measurement of VSWR, eliminates the usual necessity of matching transformers and tuning stubs.
5. Checking impedance in antenna to line match.

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BIRD ELECTRONIC

Instrumentation for Coaxial Transmission

NEW BOOKS

Scientists Against Time

By JAMES PHINNEY BAXTER, *3rd, President of Williams College. Atlantic—Little, Brown, Boston, Mass.,* 1946, 473 *pages,* $5.00.

DEDICATED "To the Scientists of the United Nations who gave their lives in the cause of freedom," this official history of the Office of Scientific Research and Development tells of the plans, the hopes, the endless experiments, the day-and-night labor under pressure and secrecy that lay behind the ultimate success of our scientists in outstripping the enemy.

This history of the mobilization of civilian science for war was initiated by Dr. Vannevar Bush who, in February 1943, persuaded Dr. Baxter, then deputy director of the Office of Strategic Services, to undertake the job. The author was given access to the official records of the Army, the Navy, and OSRD; he visited laboratories, attended service demonstrations of the new weapons, and interviewed many scientists.

Here for the first time is the full story of how we started with the formation of OSRD in June 1940; how Anglo-American radar finally surpassed the German; how new weapons were developed to meet each new emergency. The book is divided into six parts, the last of which is appropriately devoted to the atomic bomb.

Part I is 118 pages of fascinating orientation, covering the roles of submarine, naval, amphibious, air, and land warfare in relation to each other on the various battlefronts, along with the relation of science to strategy in wartime.

Part II is essentially electronic, contains 134 pages (the longest section in the book), and presents in sequence the roles played by radar and loran, radar countermeasures, contributions to subsurface warfare, new devices for air warfare, rockets, fire control, and proximity fuzes.

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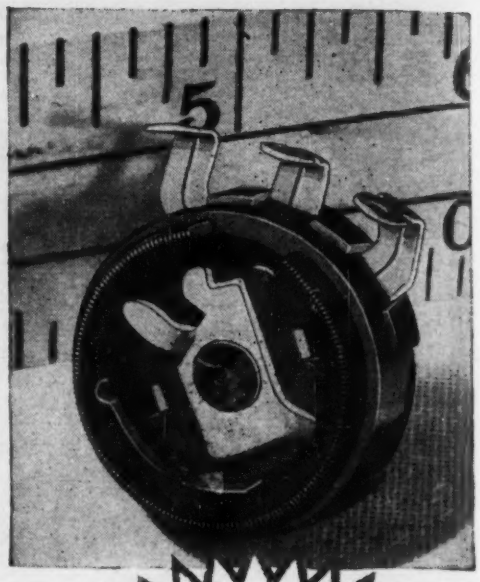

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Bakelite body with protective metal cover (shown removed in illustration).
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Power rating: 2 watts average.
Single tap at center can be provided. Tapers not practical.
300° mechanical rotation, 280° electrical, without switch; 260° with switch.

★ For engineering data on this handy midget wire-wound control, write for Bulletin No. 116.

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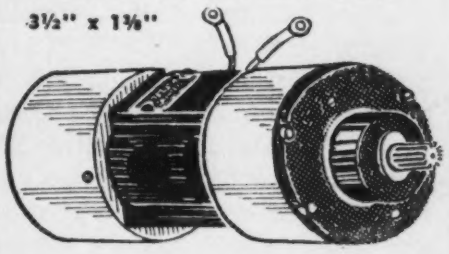
3½" x 1⅜"



Operates on Flashlight batteries, speed depending on the voltage. Fairly strong on 6 volts, full power and speed on 27 volts. Designed to be used in bombsights, automatic pilots, etc. Two types, 145 or 250 RPM. Either speed a bargain at..... **$5.00**

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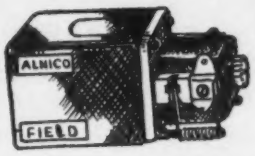

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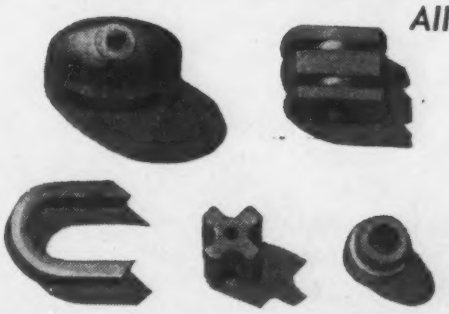

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Write for complete information to: *General Electric Company, Electronics Department, Syracuse 1, N. Y.*

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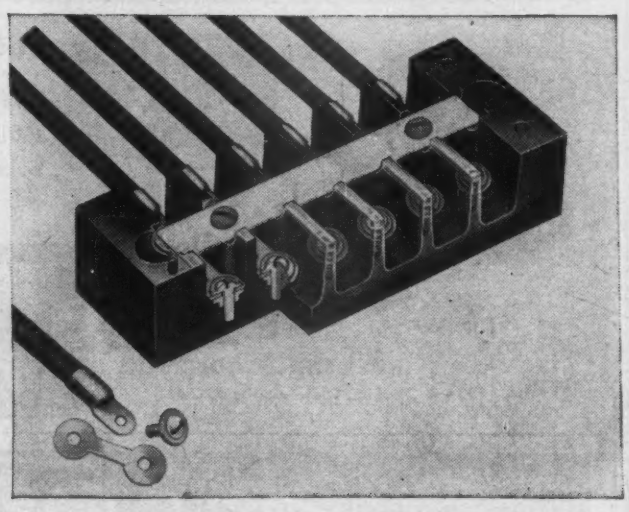

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all time as an authenic scientific history of World War II. True, there will be highly specialized volumes reporting on specific projects in minute detail, such as the MIT Radiation Laboratory series, but for most readers this well-prepared and comprehensive history will suffice; furthermore, even those waiting for the detailed volumes will find this book extremely valuable in its presentation of the overall picture. Here each OSRD project in turn is taken up, including many that were relatively unknown and only recently released from secrecy. Here too are equally interesting stories of the many projects abandoned for one reason or another, such as the Pelican—a depth bomb that was dropped from a plane and followed a radar beam produced by the plane so as to give automatic homing on a ship or submarine target. The Navy's verdict here was "no operational use".

An appendix gives among other things the number of contracts held by principal industrial and nonindustrial contractors with OSRD and the total dollar value of contracts held by each company. The index is comprehensive. The foreword is by Vannevar Bush, whose own words aptly express the undercurrent theme of the book:

"But it tells also of something that is more fundamental even than this diversion of the progress of science into methods of destruction. It shows how men of good will, under stress, can outperform all that dictatorship can bring to bear—as they collaborate effectively, and apply those qualities of character developed only under freedom."

The achievements of scientists working voluntarily against time, as presented in this book, constitute a tremendous argument for permanent worldwide peace. The implication is obvious, that no agressor can expect to survive for long if this army of scientists is ever called up again to fight for freedom.—J. M.

The Gas-Filled Triode

By G. WINDRED, *Hulton Press, Ltd., London*, 1946, 72 *pages*, 2/6.

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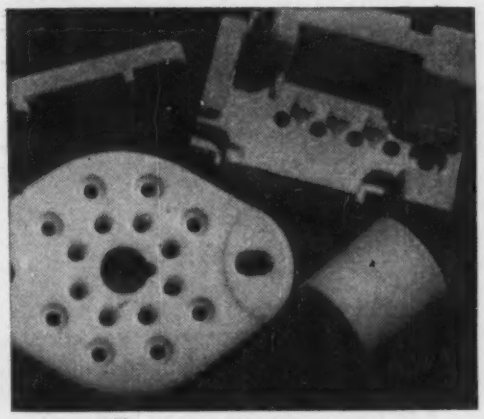

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those unfamiliar with the subject. Although this monograph contains no new material, it does present concisely and clearly all the essential facts about the tubes and their more usual applications including rectification, inversion, and motor control. The presentation is qualitative, design equations and typical values being seldom given. The discussion includes gas tetrodes. —F. R.

The Diffraction of X-Rays and Electrons by Free Molecules

By M. H. PIRENNE, *Cambridge University Press and The Macmillan Co.*, 1946, 160 *pages.*

THIS RESUME of one of the advanced physical methods of studying the microcosm presents the experimental evidence and the theoretical inferences built thereon in a logical order without resorting to obscuring mathematical treatments. The discussion is an addition to the Cambridge Series of Physical Chemistry.—F. R.

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Of Electronics, published monthly (semi-monthly in June) at Albany, N. Y., for October 1, 1946.
State of New York }
County of New York } ss.

Before me, a Notary Public in and for the State and county aforesaid, personally appeared J. A. Gerardi, who, having been duly sworn according to law, deposes and says that he is the Secretary of the McGraw-Hill Publishing Company, Inc., publishers of Electronics and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, to wit:

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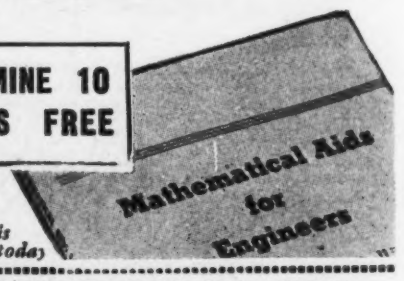

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ADDITIONS and CORRECTIONS

to the

JUNE 1946-1947 ELECTRONICS BUYERS' GUIDE

The following listings are to be used in conjunction with the June 1946—1947 ELECTRONICS BUYERS' GUIDE for information on manufacturers' names, addresses, and products omitted or incorrectly listed in that issue. Product classification numbers and names are the same as used in the June Guide.

19. RAILROAD COMMUNICATION SYSTEMS

General Electric Co., Schenectady, N. Y.

31. ELECTRIC PHONOGRAPHS and RECORD PLAYERS

General Electric Co., Bridgeport, Conn.
Rexon, Inc., 295-5th Ave., New York 16, N. Y.

36. RADAR RECEIVERS

General Electric Co., Syracuse, N. Y.

38. TRANSMITTERS

General Electric Co., Syracuse, N. Y.

41. AM PORTABLES

General Television & Radio Corp., 2701 No. Lehmann St., Chicago 14, Ill.

56. AIRCRAFT RECEIVERS

General Electric Co., Syracuse, N. Y.

67. MARINE RECEIVERS

General Electric Co., Syracuse, N. Y.

72. TELEVISION RECEIVERS

General Electric Co., Bridgeport, Conn.

86. TELEVISION SYSTEMS, INDUSTRIAL

General Electric Co., Syracuse, N. Y.

129. HUMIDITY CONTROLS

Tagliabue Div., C. J., Portable Products Corp., 550 Park Ave., Brooklyn 5, N. Y.

140. PRESSURE CONTROLS

Tagliabue Div., C. J., Portable Products Corp., 550 Park Ave., Brooklyn 5, N. Y.

145. SMOKE DENSITY COMBUSTION and CONTROLS

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147. TEMPERATURE CONTROLS

Tagliabue Div., C. J., Portable Products Corp., 550 Park Ave., Brooklyn 5, N. Y.

149. TIMING CONTROLS

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208. MOISTURE METERS

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209. pH METERS, RECORDERS and COMPARATORS

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255. DIATHERMY ACCESSORIES

Wappler, Inc., 27 W. 24th Street, New York 10, N. Y.

261. ELECTRIC WAVE GENERATORS

Wappler, Inc., 27 W. 24th Street, New York 10, N. Y.

285. BRIDGES

Tagliabue Div., C. J., Portable Products Corp., 550 Park Ave., Brooklyn 5, N. Y.

340. GALVANOMETERS

Tagliabue Div., C. J., Portable Products Corp., 550 Park Ave., Brooklyn 5, N. Y.

361. THERMOCOUPLE METERS

Tagliabue Div., C. J., Portable Products Corp., 550 Park Ave., Brooklyn 5, N. Y.

439. ANTENNA KITS

General Electric Co., Syracuse, N. Y.

477. METAL CABINETS

Paul & Beekman Div., Portable Products Corp., 1801 Cortland St., Phila., Pa.

485. SHIELDED CABLE

Precision Tube Co., 3828 Terrace St., Phila. 28, Pa.

488. CANS

Paul & Beekman Div., Portable Products Corp., 1801 Cortland St., Phila., Pa.

495. MICA FIXED CAPACITORS

General Electric Co., Syracuse, N. Y.

518. AUDIO and POWER CHOKES

Empire Coil Co., 238 Huguenot St., New Rochelle, N. Y. (Audio)

533. RELAY and SOLENOID COILS

Empire Coil Co., 238 Huguenot St., New Rochelle, N. Y.

596. FASTENERS and FASTENING DEVICES

duPont de Nemours & Co., Inc., E.I., Explosive Rivets Div., Wilmington 98, Del.

656. RODS

Franklin Fibre Lamitex Corp., 12th & French Sts., Wilmington, Del.

657. SCREW MACHINE PARTS

Franklin Fibre Lamitex Corp., 12th & French Sts., Wilmington, Del.

658. SHEETS

Franklin Fibre Lamitex Corp., 12th & French Sts., Wilmington, Del.

660. FIBRE STAMPINGS and PUNCHINGS

Franklin Fibre Lamitex Corp., 12th & French Sts., Wilmington, Del.

666. FIBRE INSULATION TUBES

Franklin Fibre Lamitex Corp., 12th & French Sts., Wilmington, Del.

670. PLASTIC INSULATION TUBES

Franklin Fibre Lamitex Corp., 12th & French Sts., Wilmington, Del.

675. CERAMIC INSULATORS

General Electric Co., Syracuse, N. Y.

716. METAL STAMPINGS, Small

Paul & Beekman Div., Portable Products Corp., 1801 Cortland St., Phila., Pa.

823. RIVETS

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840. TUBE SHIELDS

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853. INSTRUMENT HAIRSPRINGS

Instruments Specialties Co. Inc., 254 Bergen Blvd., Little Falls, N. J.

854. PRECISION SPRINGS

Instruments Specialties Co. Inc., 254 Bergen Blvd., Little Falls, N. J.

857. STRAIN RELIEFS

Walker Co., George, 118 Amsterdam Ave., Passaic, N. J.

897. TERMINAL STRIPS

Langevin Co., Inc., The, 37 West 65th St., New York 23, N. Y.

901. AUDIO and POWER TRANSFORMERS

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Empire Coil Co., 238 Huguenot St., New Rochelle, N. Y. (Audio)

902. AUTO-TRANSFORMERS

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Langevin Co., Inc., The, 37 West 65th St., New York 23, N. Y.

907. MICROPHONE TRANSFORMERS

Airdesign Inc., 241 Fairfield Ave., Upper Darby, Pa.

909. MINIATURE TRANSFORMERS

Airdesign Inc., 241 Fairfield Ave., Upper Darby, Pa.

911. PULSE TRANSFORMERS

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927. BASES

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936. GRIDS and SUPPORTS

National Carbon Co., Inc., 30 East 42nd St., New York 17, N. Y.

944. BALLAST TUBES

Kuthe Labs. Inc., 150 Summit Street, Newark 4, N. J.

959. RECTIFYING TUBES

Electrons Inc., 127 Sussex Ave., Newark, N. J.

964. THYRATRONS

Electrons Inc., 127 Sussex Ave., Newark, N. J.

976. TURNTABLE UNITS

Rek-O-Kut Co., 146 Grand St., New York 13, N. Y.

977. VALVES, SOLENOID

Tagliabue Div., C. J., Portable Products Corp., 550 Park Ave., Brooklyn 5, N. Y.

1008. ELECTROSTATIC AIR CLEANERS

Raytheon Mfg. Co., Electronic Equip. Div., Waltham 54, Mass.

1019. METAL BOXES

Walter Co., S., 144 Centre St., Brooklyn 31, N. Y.

1036. FANS AND BLOWERS

Smith Mfg. Co., F. A., P. O. Box 509, Rochester 2, N. Y.

1078. FABRIC INSULATION

Varflex Corp., N. Jay St., Rome, N. Y.

1080. FIBERGLAS INSULATION

Varflex Corp., N. Jay St., Rome, N. Y.

1091. SCREWDRIVERS and SMALL INSULATED TOOLS

Standard Pressed Steel Co., Jenkintown, Pa.

1099. CUTTING HEAD MACHINES

Rek-O-Kut Co., 146 Grand St., New York 13, N. Y.

1116. WIRE STRIPPING MACHINES

Lead-All Products Co., 24 E. 21st St., New York 10, N. Y.

1123. BERYLLIUM and BERYLLIUM ALLOYS

Beryllium Corp., The, Reading, Pa.

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1211. METAL and ALLOY TUBING

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1213. NICKEL TUBING

Carpenter Steel Co., Kenilworth, N. J.

1215. STEEL TUBING

Carpenter Steel Co., Kenilworth, N. J.

NAME and ADDRESS

CORRECTION or CHANGE

Bradley Laboratories, 82 Meadow Street, New Haven, Conn.
Tibbetts Industries, Inc., Camden, Maine

A NOTE FROM THE EDITORS

The above list of additions and corrections together with the one published in the November Issue bring the 1946–1947 Electronics Buyers' Guide fully up to date on the basis of information now available. No further monthly listings will be published for use in conjunction with the 1946–1947 Guide. All pertinent directory information received in the months ahead will be held for publication in the 1947–1948 Guide (coming June 1947).

Manufacturers of electronic components, equipment, and allied products are urged to watch for the questionnaire which we shall send them shortly, requesting a complete list of the products they manufacture to be included in the 1947–1948 Buyers' Guide. Complete, accurate product listings by manufacturers are indispensable to us in the preparation of the Guide, and, wherever possible, product literature in the form of brochures, booklets, data sheets etc. should accompany the returned questionnaire. Careful completion of this questionnaire will help us greatly in producing an accurate and all-inclusive listing in the 1947–1948 Buyers' Guide.

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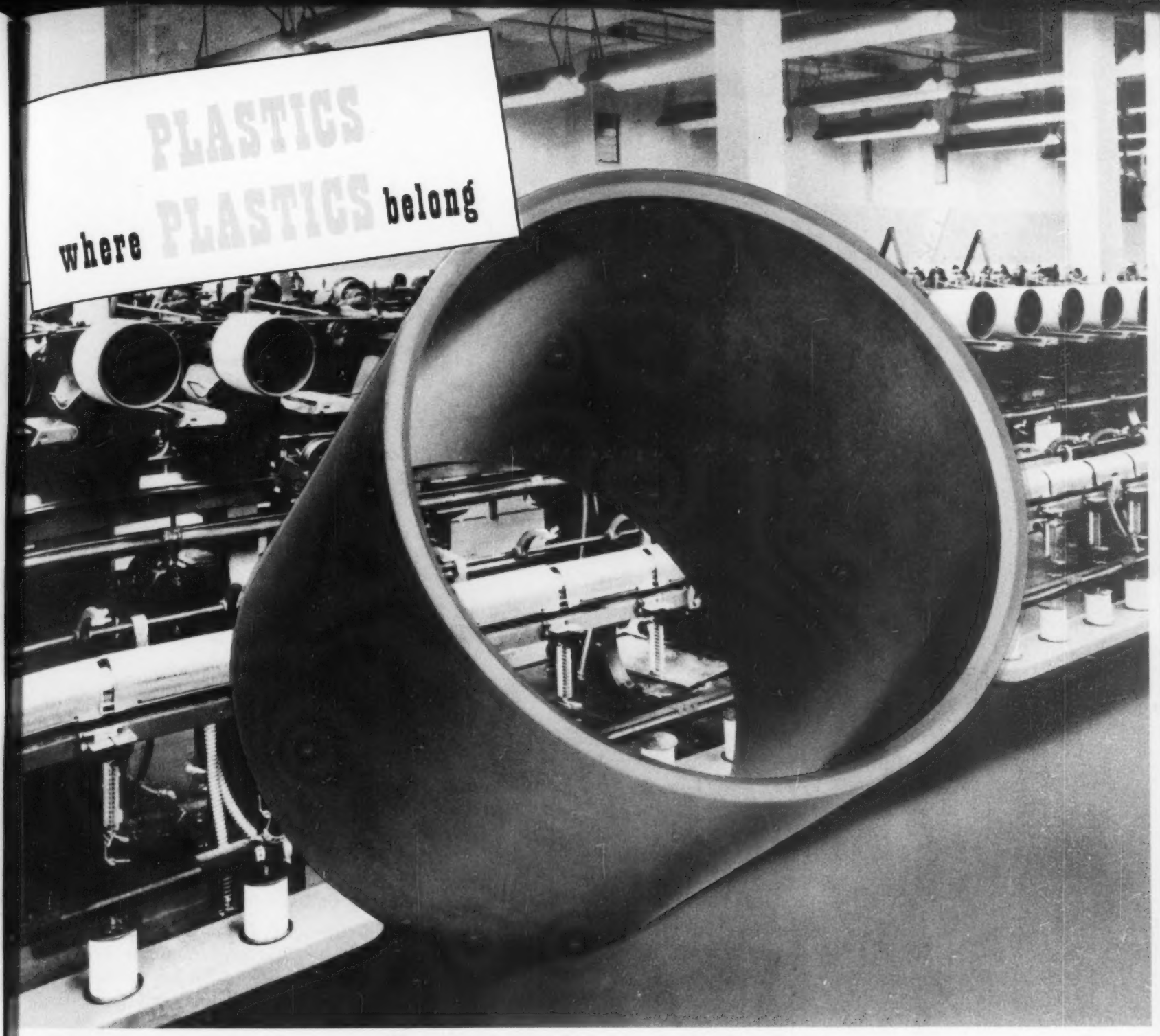

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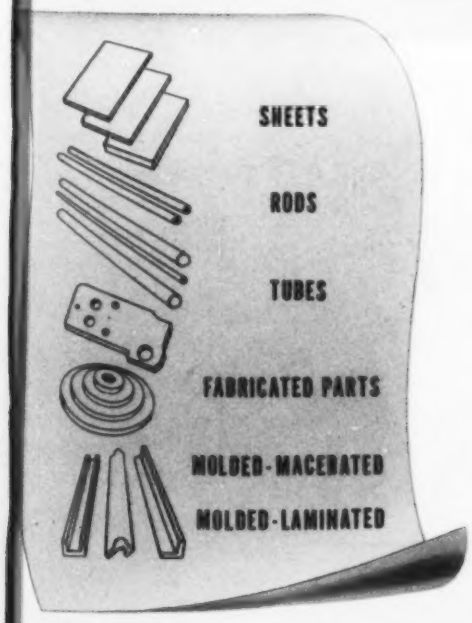

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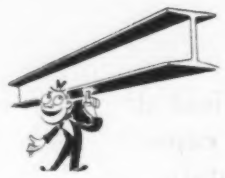

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CAPACITORS

COMMON SENSE ASSEMBLY ENGINEERING

Model builders with an average amount of skill and ordinary household tools can put this nifty little plane together without any trouble, thanks to the simpler P-K fastening method.

Before starting production of this first all-metal model plane, the Vahl Engineering Company made an exhaustive study of assembly and found that P-K Self-tapping Screws eliminated the problems anticipated with more complicated fastenings.

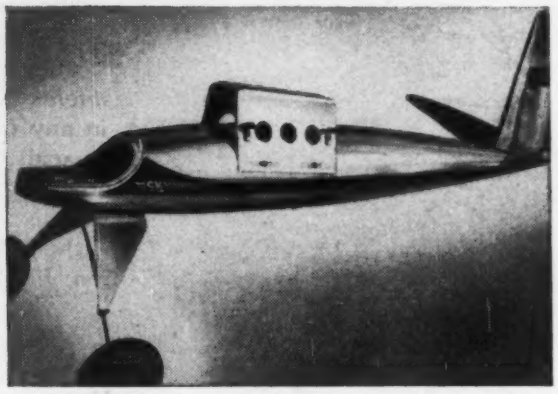
No tricky methods or special equipment are necessary. The model builder simply drills holes and drives the P-K Screws, which form their own threads, hold firmly.

The same P-K advantages of speed and simplicity have repeatedly saved large airplane manufacturers valuable time and labor . . . by eliminating tapping, bolting, riveting.

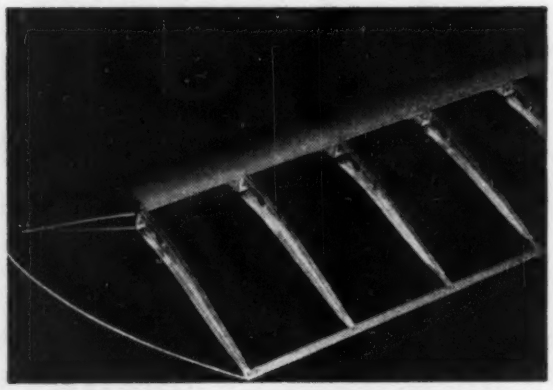
It's plain common sense to apply these P-K advantages in your product assembly, wherever possible. In 7 out of 10 jobs studied, P-K Screws permitted savings in time and labor, often from 30% to 50%. Call in a P-K assembly engineer and discuss your fastenings with him, or, send assembly details to us for recommendations. Write Parker-Kalon Corp., 200 Varick St., New York 14, N. Y.

Sold Only Through Accredited Distributors

104 P-K Type "Z" Self-tapping Screws are furnished for assembling the fuselage, wings, cabane stabilizer and rudder of this Metaline Skyvahl Model Plane.



P-K binding head Type "Z" Screws fasten cabane to fuselage. Slots permit wing assembly to be moved back when model is changed over from "Class B" to "Class C", with heavier motor.



There are 15 P-K Self-tapping Type "Z" Screws in each wing structure, fastening spar, ribs, leading edge and tip securely together.

FEDERAL'S BALANCED HF CABLE KT-51 HAS THE RIGHT TWIST

for Peak Performance of FM and Television Receivers

HERE'S A NEW HF cable that will keep your FM and Television receivers working at peak performance—free from locally-induced interference, even in the most adverse locations. Where the performance of such costly equipment is at stake, it will pay you to specify Federal's KT 51—the finest high frequency lead-in cable available. More costly—but *worth* more!

The *twisted,* dual-conductor cable cancels any noise or signals not stopped by the double *braided shields* . . . because it's electrically balanced and stays that way in service, in any position. It's a rugged cable, too—remarkably resistant to abrasion, acids, alkalies, oils and greases, as well as smoky atmospheres and weather.

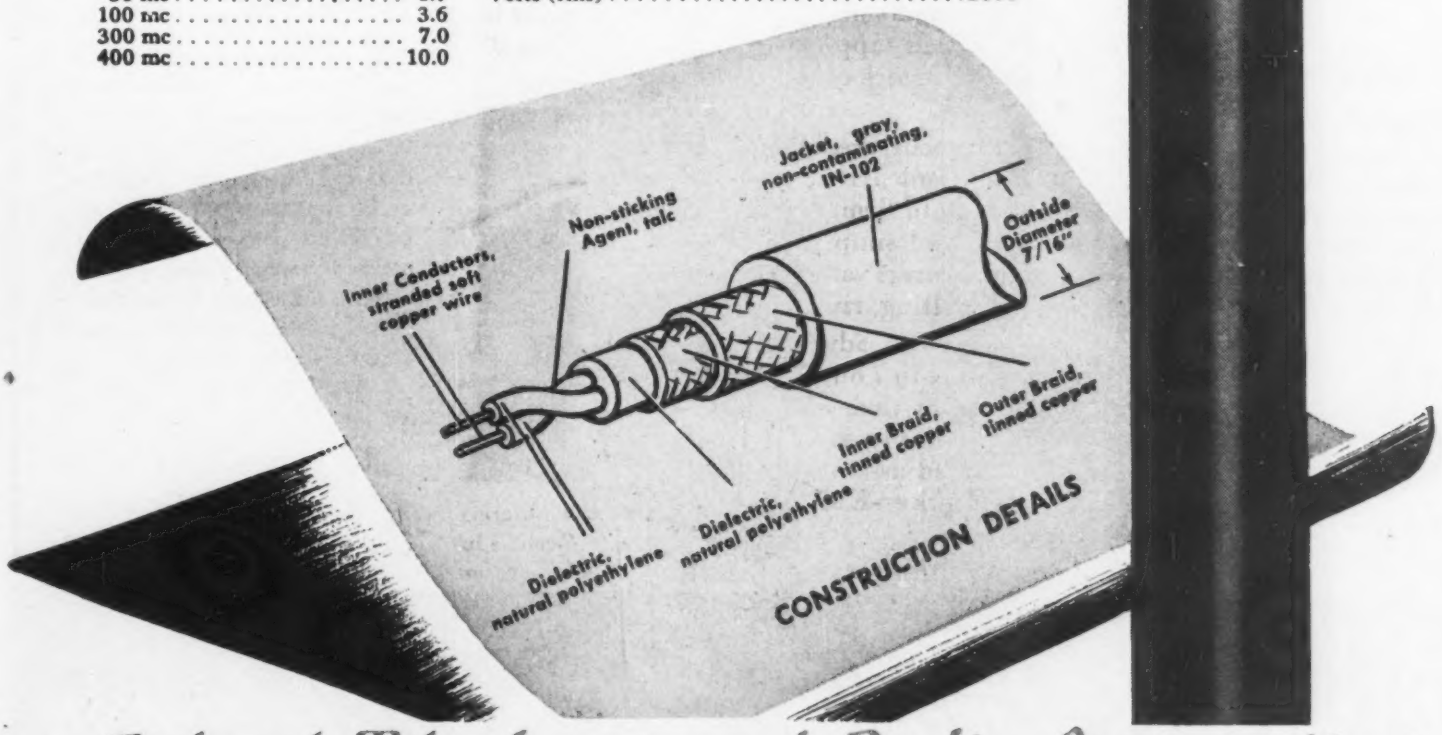
Don't let the lead-in wire be the "weak link" in otherwise perfect equipment. Be sure it's KT 51—the HF cable with the "right twist" to assure interference-free operation. For complete details, write to Dept. D-613.

ELECTRICAL CHARACTERISTICS

Nominal Attenuation (db/100 ft.)

Frequency	*Attenuation*
10 mc	0.9
30 mc	1.7
100 mc	3.6
300 mc	7.0
400 mc	10.0

Maximum Capacity Unbalance	1%
Nominal Characteristic Impedance (ohms)	95
Nominal Capacitance per ft. (uuf)	16
Volts (rms)	2000



Federal Telephone and Radio Corporation

In Canada:—Federal Electric Manufacturing Company, Ltd., Montreal
Export Distributor—International Standard Electric Corporation, 67 Broad St., N. Y. C.

An IT&T Associate

Newark 1, New Jersey

Du Mont has many *Accessories* for your Cathode-Ray Equipment...

CALIBRATED SCALES

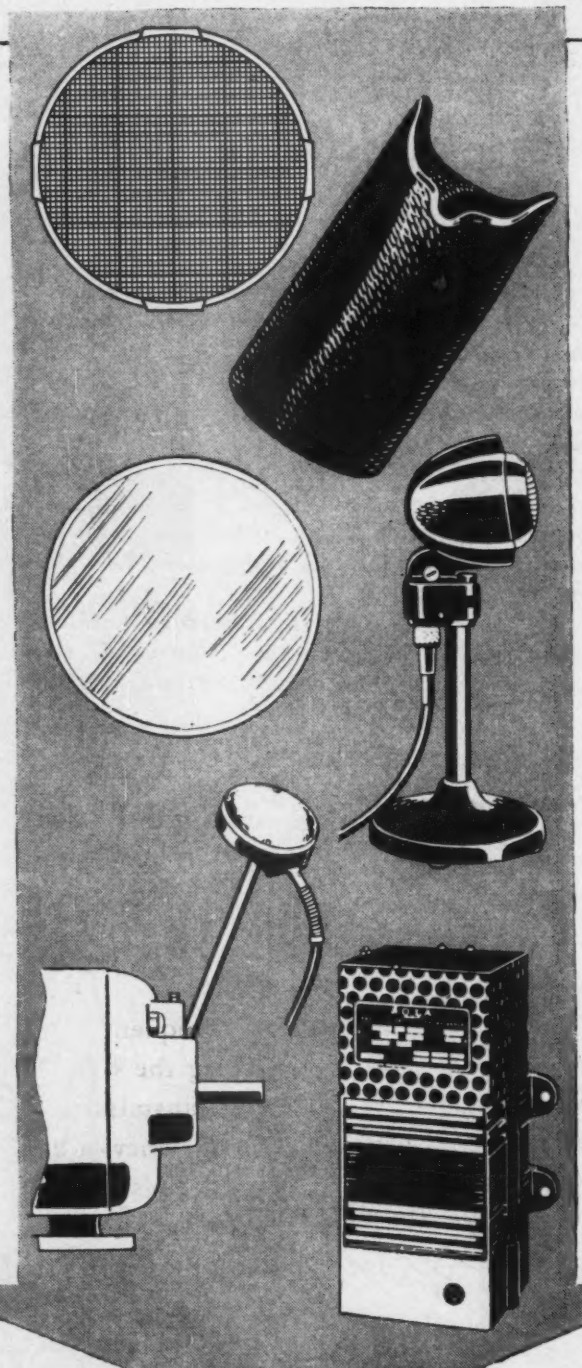
Provide a convenient means for making calibrated and quantitative measurements with a cathode-ray oscillograph. Types 216 are available in 3-inch and 5-inch rectangular coordinate scales calibrated in inches and tenths of inch; also in 5-inch polar coordinate scales. 5-inch logarithmic scales are also available for direct-reading of logarithmic decrements or Q measurements.

COLOR FILTERS

Increase contrast and relieve eye-strain by filtering out all but the desired light. Available in the 5-inch size for use with blue, green or amber screens. Made of plexiglass which fits between the calibrated scale and the face of the cathode-ray tube.

VIBRATION PICKUPS

Types VP-5 and DP-1 convert vibrations into electrical potentials which can be applied to the input circuit of the oscillograph. The response of the VP-5 is proportional to velocity; that of the DP-1 is proportional to displacement. The DP-1 is especially suited to low-frequency work.



Write for descriptive literature

VIEWING HOOD

Use our Type 276 rubber viewing hood to shield the eyes and the tube screen when observing oscillographic patterns under unfavorable ambient light conditions. It fits any oscillograph equipped with a 5-inch cathode-ray tube.

CRYSTAL MICROPHONE

The Type 277, of unusually high impedance, is specially designed for direct connection to cathode-ray oscillograph input circuits. The directional response is practically circular in both horizontal and vertical planes at all audio frequencies.

CONSTANT-VOLTAGE TRANSFORMER

A "must" where irregularity of supply voltage interferes with the performance of oscillographic equipment. The Type 283 is designed for operation from 60-cycle, single-phase alternating current. It delivers a constant secondary-output potential of 115 volts, at loads up to 250 volt-amperes, for input-potential variations from 95 to 125 volts.

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DUMONT *Precision Electronics & Television*

ALLEN B. DUMONT LABORATORIES, INC., PASSAIC, NEW JERSEY • CABLE ADDRESS: ALBEEDU, PASSAIC, N. J., U. S. A.

SEND FOR OUR NEW 4-PAGE GEAR CATALOG

Small Gears are made in almost endless variety. Frequently their applications are entirely without precedent. This was especially true during the war. New principles, new design, new engineering, a different approach to power transmission problems . . all these things and more are often required to produce the greater efficiency and economy of G.S. Fractional Horsepower Gears. The G. S. Gear Catalog just printed, illustrates and describes many different types and applications of G. S. Small Gears. It offers valuable aid to *anyone* concerned with specifying Gears from 12 to 96 D.P. Just ask for a copy on your company stationery. No cost or obligation is involved.

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MEMBER OF AGMA

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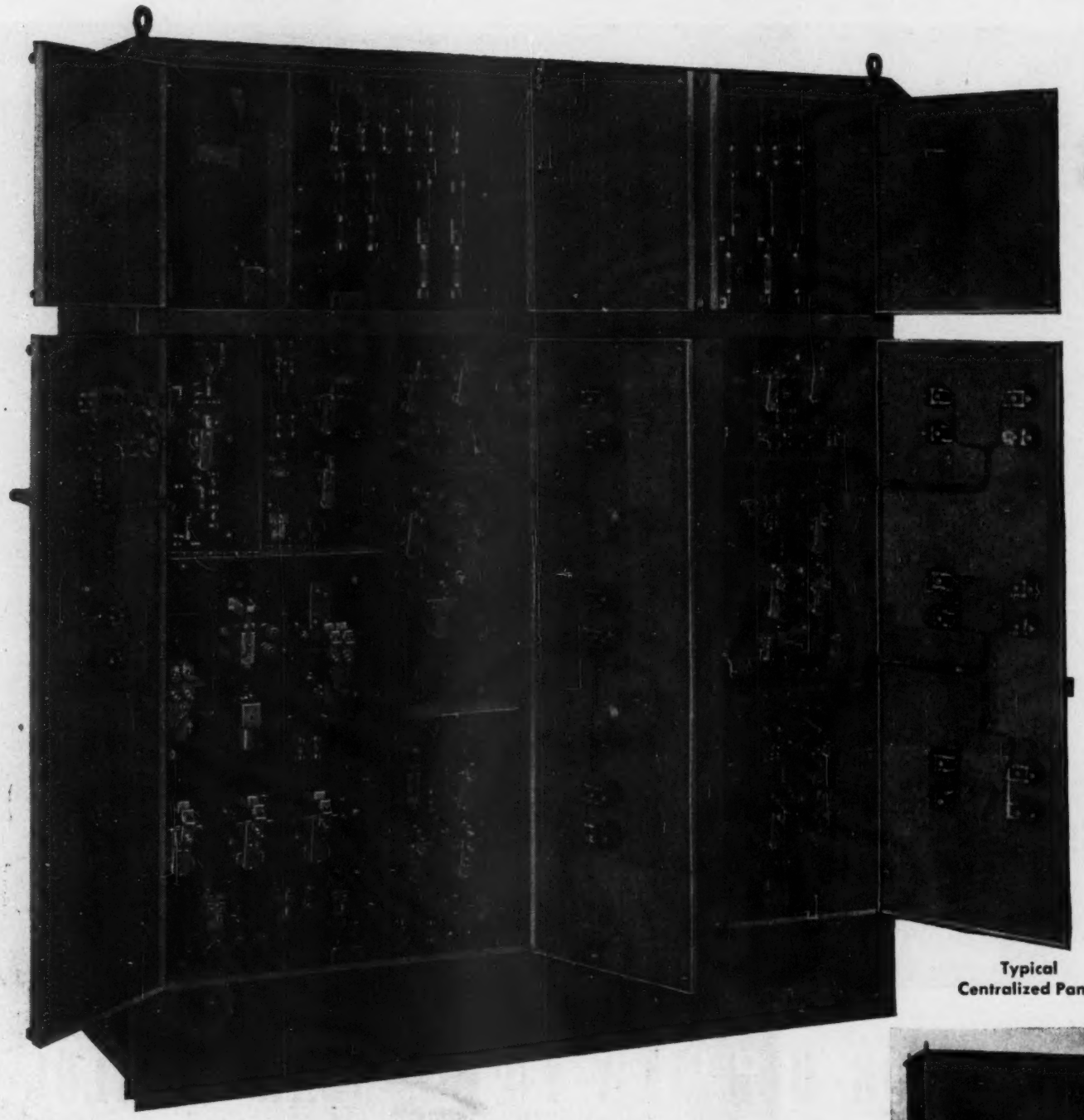


Typical
Centralized Panel

WITH CENTRALIZED CONTROL ONE MAN IN ONE PLACE CONTROLS EVERYTHING

Convenience and accessibility of controls are but two of the many potent arguments for centralized control. Here are a few of the advantages:—

SAFETY of dead front enclosure with operation of all mechanisms from the front offers greatest protection to your operator.

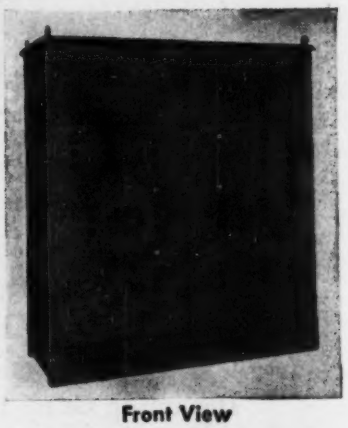
SIMPLICITY of installation and wiring results in reduced costs.

SPACE SAVING with the single enclosure is accomplished. Frameworks and wall supports are not needed.

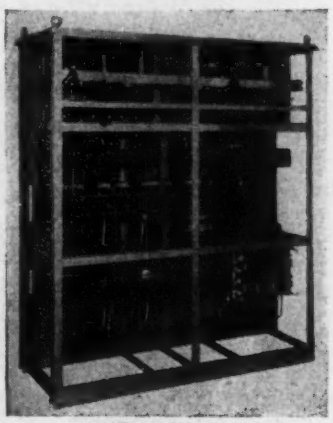
ENGINEERED CONTROL to meet your own requirements at little or nothing above the final cost of individual control units.

These are but a few of the reasons why alert engineers are specifying centralized control for modern plant installations.

Let us show you the benefits. A Ward Leonard engineer will gladly help you to select a centralized control to meet your exact needs.



Front View



Rear View

WARD LEONARD

RELAYS • RESISTORS • RHEOSTATS

Electric control devices since 1892

WARD LEONARD ELECTRIC COMPANY

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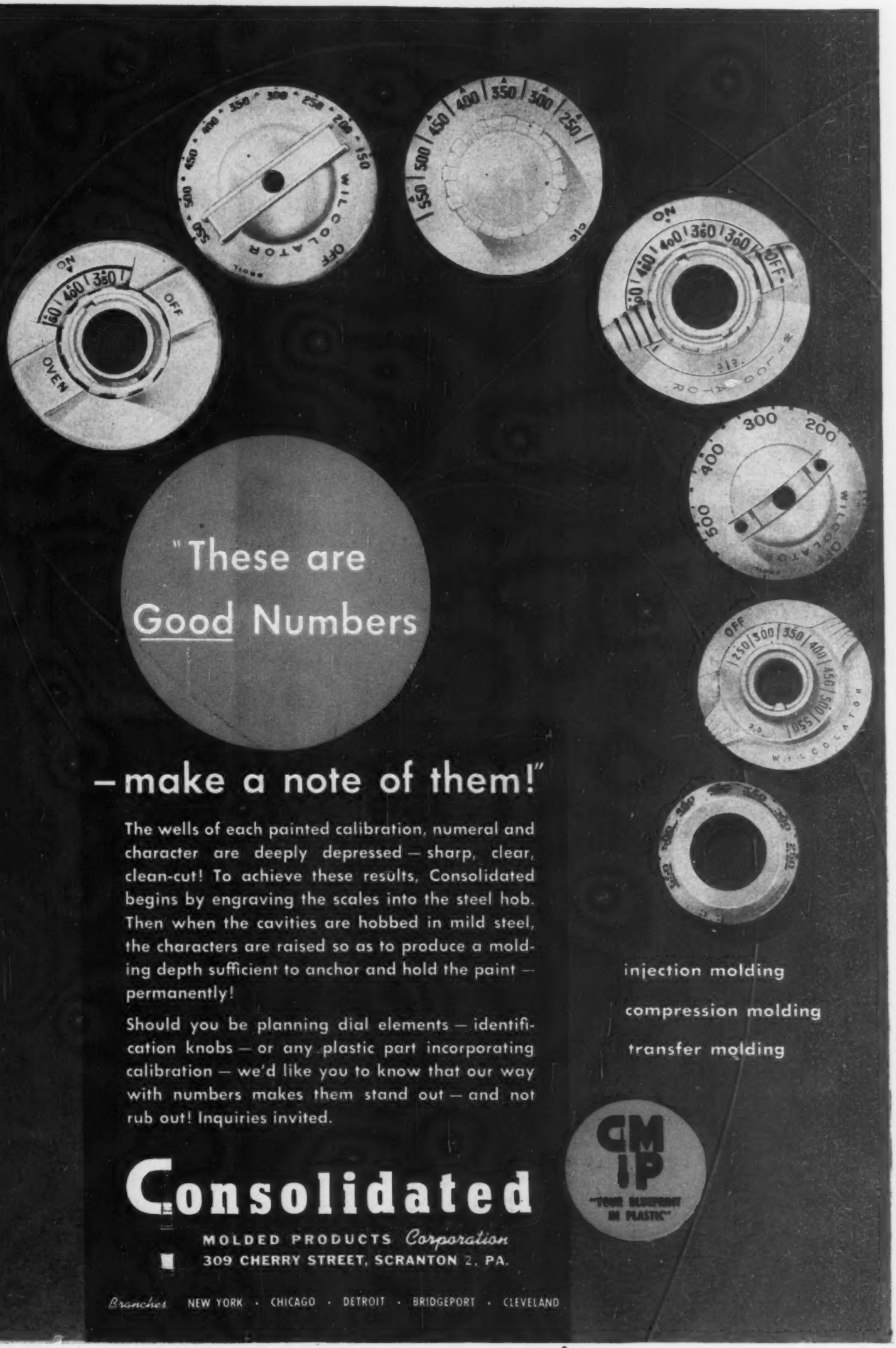
"These are
Good Numbers
– make a note of them!"
The wells of each painted calibration, numeral and character are deeply depressed – sharp, clear, clean-cut! To achieve these results, Consolidated begins by engraving the scales into the steel hob. Then when the cavities are hobbed in mild steel, the characters are raised so as to produce a molding depth sufficient to anchor and hold the paint – permanently!
Should you be planning dial elements – identification knobs – or any plastic part incorporating calibration – we'd like you to know that our way with numbers makes them stand out – and not rub out! Inquiries invited.
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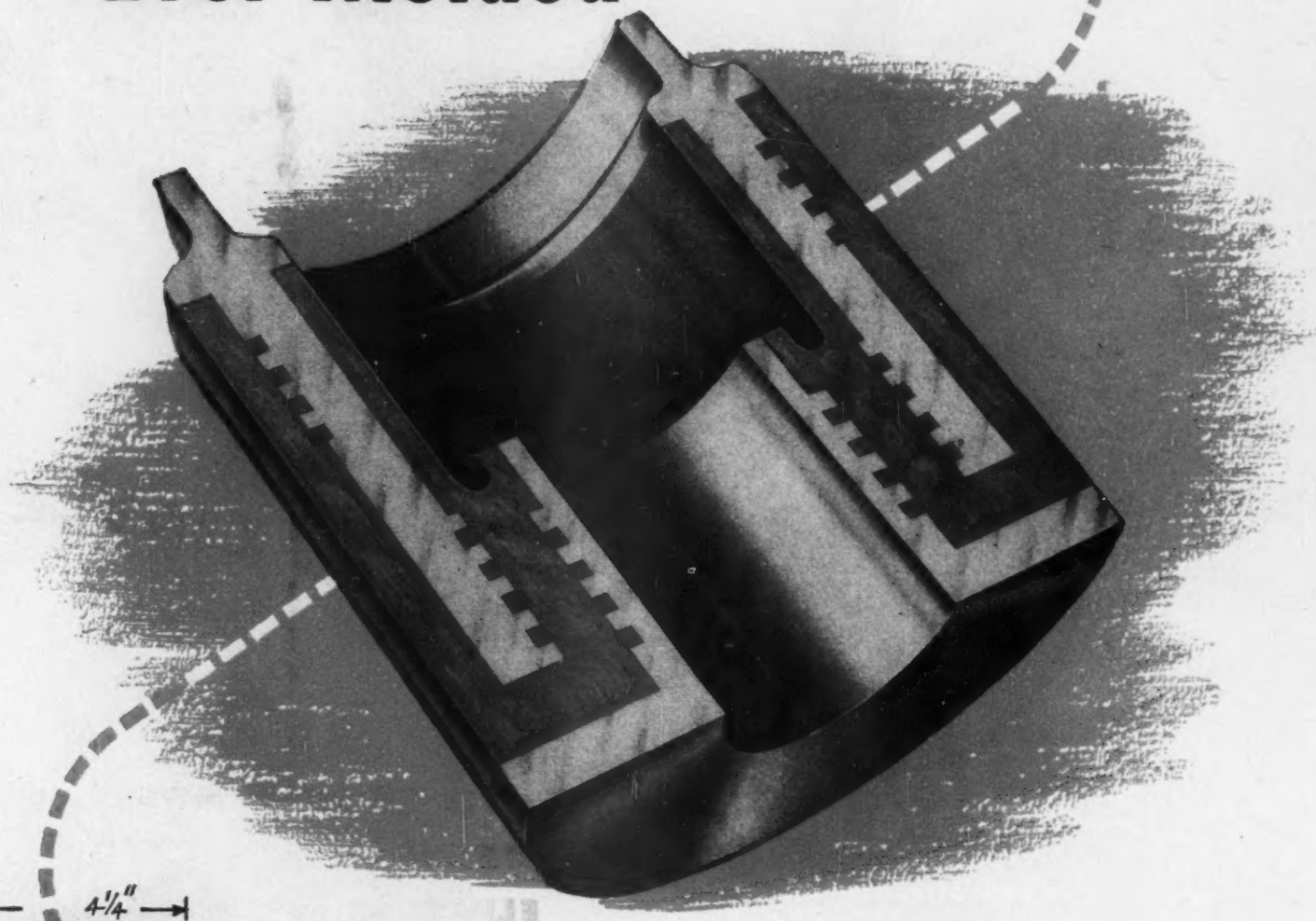
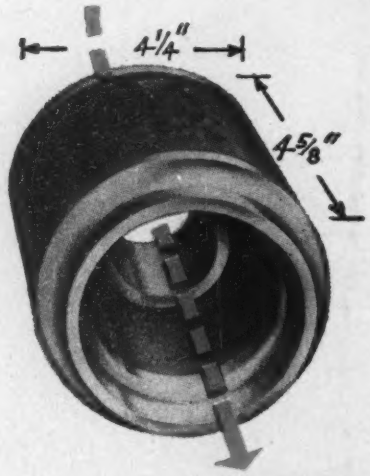
"YOUR BLUEPRINT IN PLASTIC"

Largest MYCALEX Part Ever Molded





This cross section of a MYCALEX-to-metal molded component part was made for one of the country's leading manufacturers, and is the result of close cooperation between the customer's and our own engineering staffs. It exemplifies a new development in the molding of MYCALEX 410 with metal to form a hermetic seal.

The objective was to take advantage of the low loss factor and other desirable properties of MYCALEX 410 to produce a rugged bushing assembly in a single molding operation.

A difficulty was presented by the extremely long and branched path which the MYCALEX 410 had to follow. Total charge of MYCALEX 410 was 7 pounds, while the metal weighed 6 pounds to make a total weight of 13 pounds.

The MYCALEX and metal were sealed into one closely-bonded integral part, held to extremely close dimensional tolerances.

For more than 27 years MYCALEX has met and surpassed the most exacting needs engineers have been able to devise from year to year. MYCALEX 410, together with our highly perfected methods of molding it, is the greatest advancement in this high frequency low loss insulation to date.

Our technical staff is at your service. What is your problem in low loss insulation?

SINCE 1919
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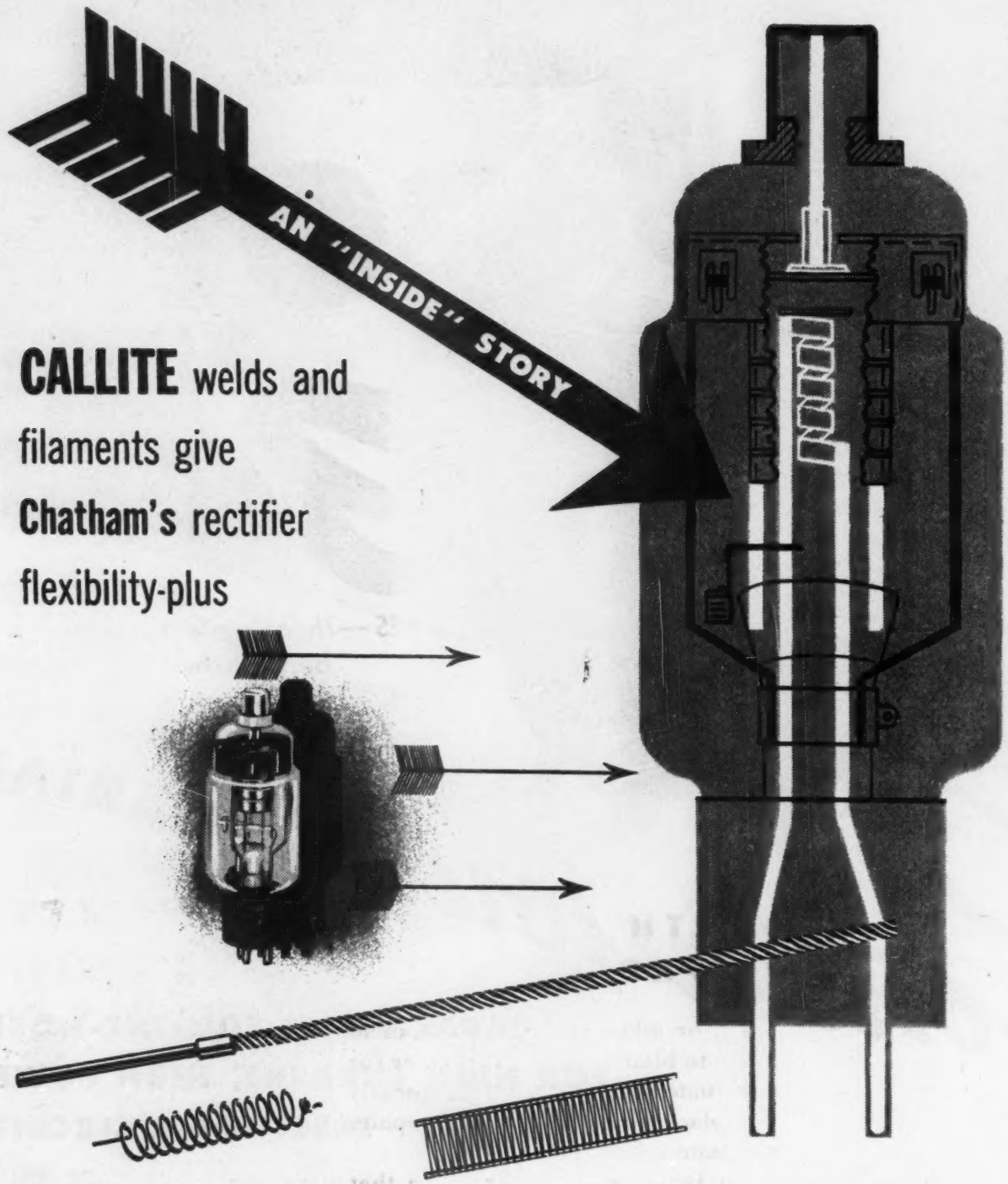
CAPACITANCE "ON-THE-NOSE" FOR HIGH CURRENT, HIGH POWER ELECTRONIC CIRCUITS

The variable capacitance feature of Lapp Gas-Filled Condensers permits you to "tune-to-a-whisker," with power on, to get the most out of any high current, high power circuit. And once set, this gas-dielectric unit delivers uniformly—no "warm up," no change of capacitance with change in temperature. Non-deteriorating, too, the Lapp unit is truly puncture-proof and will outlast almost any other components of any circuit of which it is a part. In addition to the variable unit, there are adjustable units, continuously adjustable within their range but not designed for frequent "tuning dial" adjustment, and fixed capacitance units. Current ratings range up to 500 amperes R.M.S.; power ratings to 60 Kv peak load. Capacitance to 60,000 mmf. (for fixed units); to 16,000 mmf. (variable and adjustable units). Higher ratings on special design order.

Lapp

LAPP INSULATOR COMPANY, INC., LE ROY, NEW YORK



CALLITE welds and filaments give **Chatham's** rectifier flexibility-plus

Contributing to the built-in ruggedness of this Chatham type 3B28 rectifier are vital Callite tungsten welds and filaments. Because of their inherent stamina and ready adaptability this tube is better able to stand the "gaff" of high voltage service.

Chatham Electronics designed the 3B28 rectifier to withstand heavy vibration and shock, to operate normally through an ambient temperature range of −75°C. to +90°C. This required tube components of high current carrying capability and great mechanical strength. That is why Chatham called on Callite for this vital job.

Leading electronic manufacturers have been relying for many years on Callite tube and lamp components. They have discovered that our 26 years of metallurgical pioneering produce parts which safeguard the life and performance of their products. If you have a particularly exacting or unusual problem, we can help you solve it. Consult with our engineers for practical suggestions and benefit from their successful experience. Callite Tungsten Corporation, 544-39th Street, Union City, New Jersey. Branch Offices: Chicago and Cleveland.

Callite TUBE COMPONENTS

CALLITE TUNGSTEN CORPORATION CT

Hard glass leads, welds, tungsten and molybdenum wire, rod and sheet, formed parts and other components for electron tubes and incandescent lamps.

PIONEERS IN SPECIALIZED METALLURGY

"POWER TO Burn"

YES—there's plenty of power behind the usual electric connection to burn out any electrical instrument or equipment not properly protected—if something goes wrong!

IF IT'S WORTH MAKING IT'S WORTH PROTECTING!

When a motor, instrument or other electrical equipment burns out, the user is prone to blame the manufacturer for not having provided adequate protection. It frequently means costly delays and replacement, or expensive repairs —all of which tends to create a bad impression.

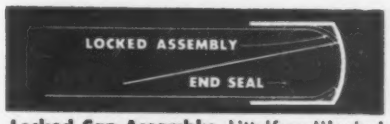
Littelfuse precision-built fuses are so inexpensive that every manufacturer of such equipment can effectively protect his products and reputation at relatively small cost. They embody special features in engineering, design and construction which insure the exacting protection *necessary* for highly critical equipment, and *desirable* on all electrical devices.

A complete range of different types and sizes for instrument protection, fusing of small motors, radio and electronic circuits, automobile, aircraft and marine instruments, and all types of electrical equipment. Fuse mountings also available for an extensive range of applications. Write, phone or wire for prices and specifications.

LITTELFUSE *Plus* FEATURES!

Vibration-Proof. Littelfuse element twisted to 90 degrees most effectively braces the fuse element against severe vibration.

Non-Crystallizing. Littelfuse "Gooseneck" provides a spring-like formation at one end of the fuse element, which prevents crystallization due to repeated expansion and contraction. There is no cracking at the fusion point.



Locked Cap Assembly. Littelfuse "Locked Caps" assembled with non-corrosive fluxes prevent interior corrosion. No difficulty in removing fuse for identification and replacement in all types of mountings after fuse is blown. Littelfuse "Locked Caps" always remain firmly in position.

LITTELFUSE FIRST IN CIRCUIT PROTECTION *Incorporated*

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• the one dependable central source of supply for everything in electrical insulation

- VARNISHES
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- VARNISHED COTTON TAPES
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- FIBERGLAS TUBING
- FIBERGLAS SLEEVINGS
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- WAXES
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Let Mitchell-Rand be your buyers guide for everything in electrical insulation

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Insulating Papers and Twines
Cable Filling and Pothead Compounds
Friction Tape and Splice
Transformer Compounds
Fiberglas Saturated Sleeving, Varnished Tubing
Asbestos Sleeving and Tape
Varnished Cambric Cloth and Tape
Mica Plate, Tape, Paper, Cloth, Tubing
Fiberglas Braided Sleeving
Cotton Tapes, Webbings and Sleevings
Impregnated Varnish Tubing
Insulating Varnishes of all types
Extruded Plastic Tubing

Jensen *Speech Master* REPRODUCERS

...for clear, crisp, intelligible Speech* Reproduction

Designed especially for speech reproduction in intercommunication and public address applications, this Speech Master family of JENSEN Reproducers, delivers clean, sharp, understandable announcements and orders. Like all JENSEN products, these Speech Masters were completely engineered to do their job efficiently and well.

MODEL NJ-300 SPEECH MASTER (Railroad Type). PM design. Widely used in railroad intercommunication in locomotives, cabooses, signal towers and yards. Rugged case protects against shock and vibration; withstands dust, smoke and the elements. Voice coil impedance 12 ohms; power rating, 10 watts. Space provided inside case for 500-ohm impedance transformer. Overall height 11-3/4"; width 6-25/32"; depth 4-13/16". Holes provided in base for mounting in any position.

MODEL AR-10 SPEECH MASTER *ALNICO 5* design. Specially constructed reflex horn increases efficiency in mid-frequency range, giving added effectiveness and "punch" to speech quality; prevents direct access of rain and snow to speaker diaphragm. Voice coil impedance, 4 ohms and 45 ohms; power rating, 6 watts. Space provided inside for ½" x ½" transformer. Overall diameter 10"; depth 8". Complete with mounting bracket.

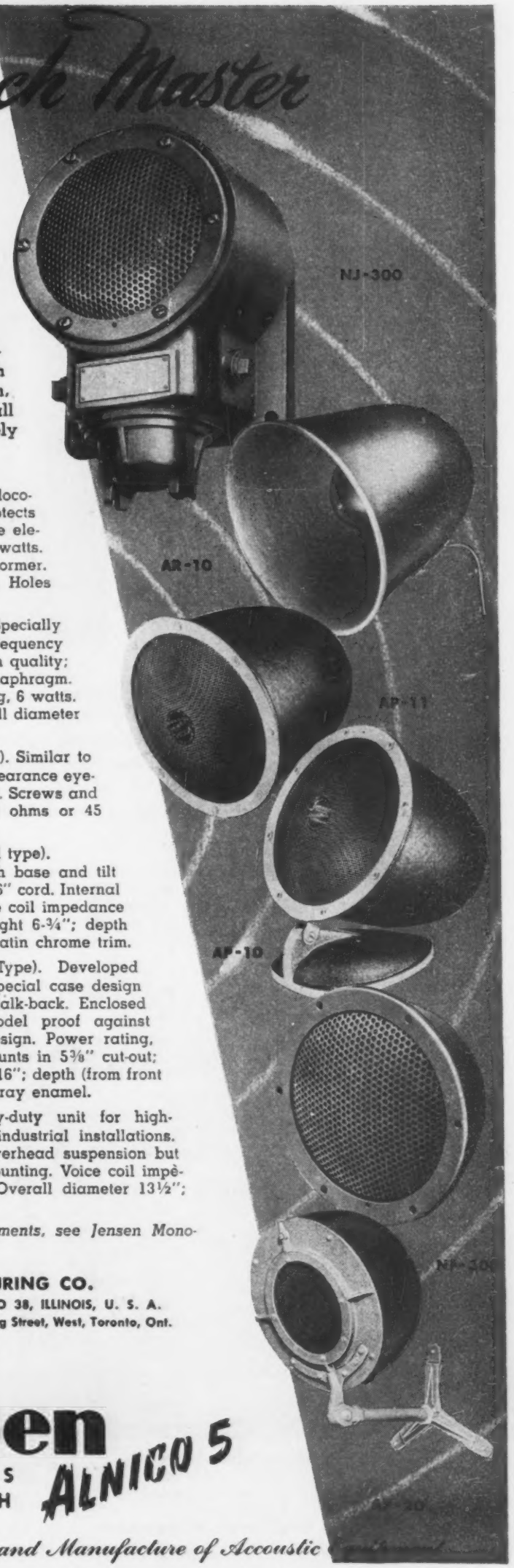
MODEL AP-11 SPEECH MASTER (Panel mounting). Similar to AP-10 but without base. Mounts in 4-27/64" cut-out; clearance eyelets for mounting screws. Depth 4½" from front panel. Screws and drilling template included. Voice coil impedance 4 ohms or 45 ohms; power rating, 5 watts.

MODEL AP-10 SPEECH MASTER (Desk or Wall type). PM design, desk or wall mounting. Complete with base and tilt adjustment. Double dustproofed. Rubber covered 36" cord. Internal mounting bracket for ½" x ½" transformer. Voice coil impedance 4 ohms or 45 ohms; power rating, 5 watts. Height 6-¾"; depth 5⅛"; diameter 5". Finish hammered gray with satin chrome trim.

MODEL NF-300 SPEECH MASTER (Navy Type). Developed for use as a loud speaker and microphone. Special case design over-rides wind and background noises for talk-back. Enclosed case and protective screen render this model proof against weather, dust and moisture *ALNICO 5* PM design. Power rating, 10 watts; voice coil impedance 12 ohms. Mounts in 5⅜" cut-out; six screw holes in rim. Overall diameter 6-7/16"; depth (from front of panel) 2-9/64". Finished in Munsel N4-5 gray enamel.

MODEL AP-20 SPEECH MASTER Heavy-duty unit for high-level paging and call systems in noisy industrial installations. PM design. Furnished with eyebolt for overhead suspension but available with stand for wall or table mounting. Voice coil impedance 8 ohms; power rating, 25 watts. Overall diameter 13½"; depth 9"

**For full discussion of Speech requirements, see Jensen Monograph No. 4.*



5 MONOGRAPHS AVAILABLE

If you haven't yet procured these five valuable technical booklets, order now—either from your dealer or direct—at 25¢ each.

1. Loud Speaker Frequency-Response Measurements
2. Impedance Matching and Power Distribution
3. Frequency Range in Music Reproduction
4. The Effective Reproduction of Speech
5. Horn Type Loud Speakers

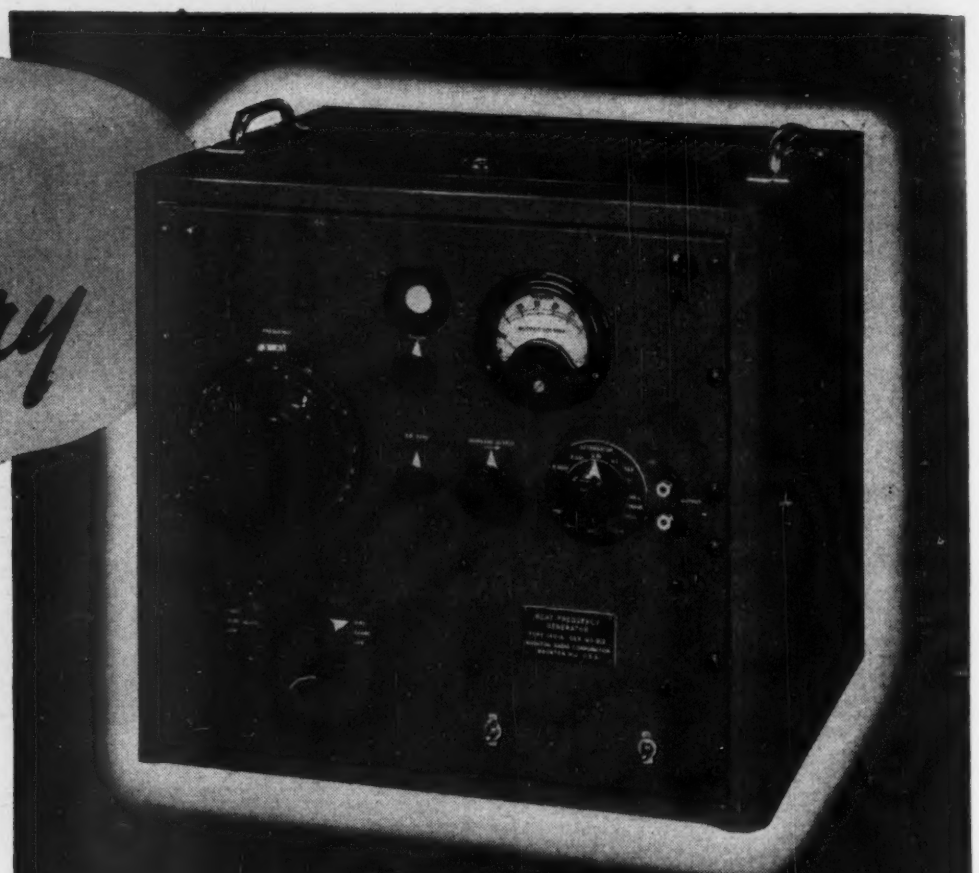
25¢ each

JENSEN MANUFACTURING CO.
6607 S. LARAMIE AVENUE, CHICAGO 38, ILLINOIS, U. S. A.
In Canada: J. R. Longstaffe, Ltd., 11 King Street, West, Toronto, Ont.

Jensen SPEAKERS WITH *ALNICO 5*

Specialists in Design and Manufacture of Acoustic

For the Laboratory



BEAT FREQUENCY GENERATOR

TYPE 140-A

This instrument has found universal acceptance because of its wide frequency coverage from 20 cycles to 5 megacycles. A five step decade attenuator provides a means by which extremely small output voltages can be accurately set and a six position switch enables any one of a variety of output impedances to be quickly selected.

SPECIFICATIONS:

FREQUENCY RANGE: 20 cycles to 5 megacycles in two ranges.
Low range: 20 to 30,000 cycles.
High range: 30 kc to 5 megacycles.

FREQUENCY CALIBRATION: Accuracy ±2 cycles up to 100 cycles, ±2% above 100 cycles.

STABILITY: About 5 cycles drift below 1000 cycles. On low range, drift becomes negligible percentage with increasing frequency. On high range, drift is 3% or less.

ADJUSTMENT: High and low ranges have individual zero beat adjustments. Low range may be checked against power line frequency with front panel 1 inch cathode ray tube.

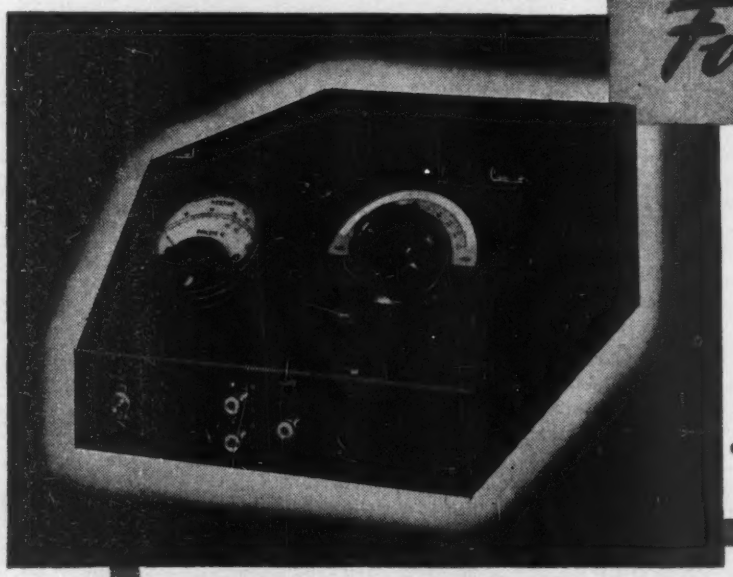
OUTPUT POWER AND IMPEDANCES: Rated power output: One watt, available over the low frequency range from output impedances of 20, 50, 200, 500, 1000 ohms, and over both high and low frequency ranges from an output impedance of 1000 ohms.

DISTORTION: 5% or less at 1 watt output, 2% or less for ½ voltage output.

VOLTMETER ACCURACY: ±3% of full scale reading.

For further details write for Catalog D

For the Production Line



QX-CHECKER *TYPE 110-A*

This production-test instrument is specifically designed to compare relative losses or Q simultaneously with inductance or capacitance in one operation and with a single setting. Built to laboratory precision standards, the QX-Checker is a sturdy, foolproof instrument for use in production work by any usual factory personnel.

SPECIFICATIONS:

FREQUENCY RANGE: 100 kc to 25 mc in 6 ranges using plug-in coils.

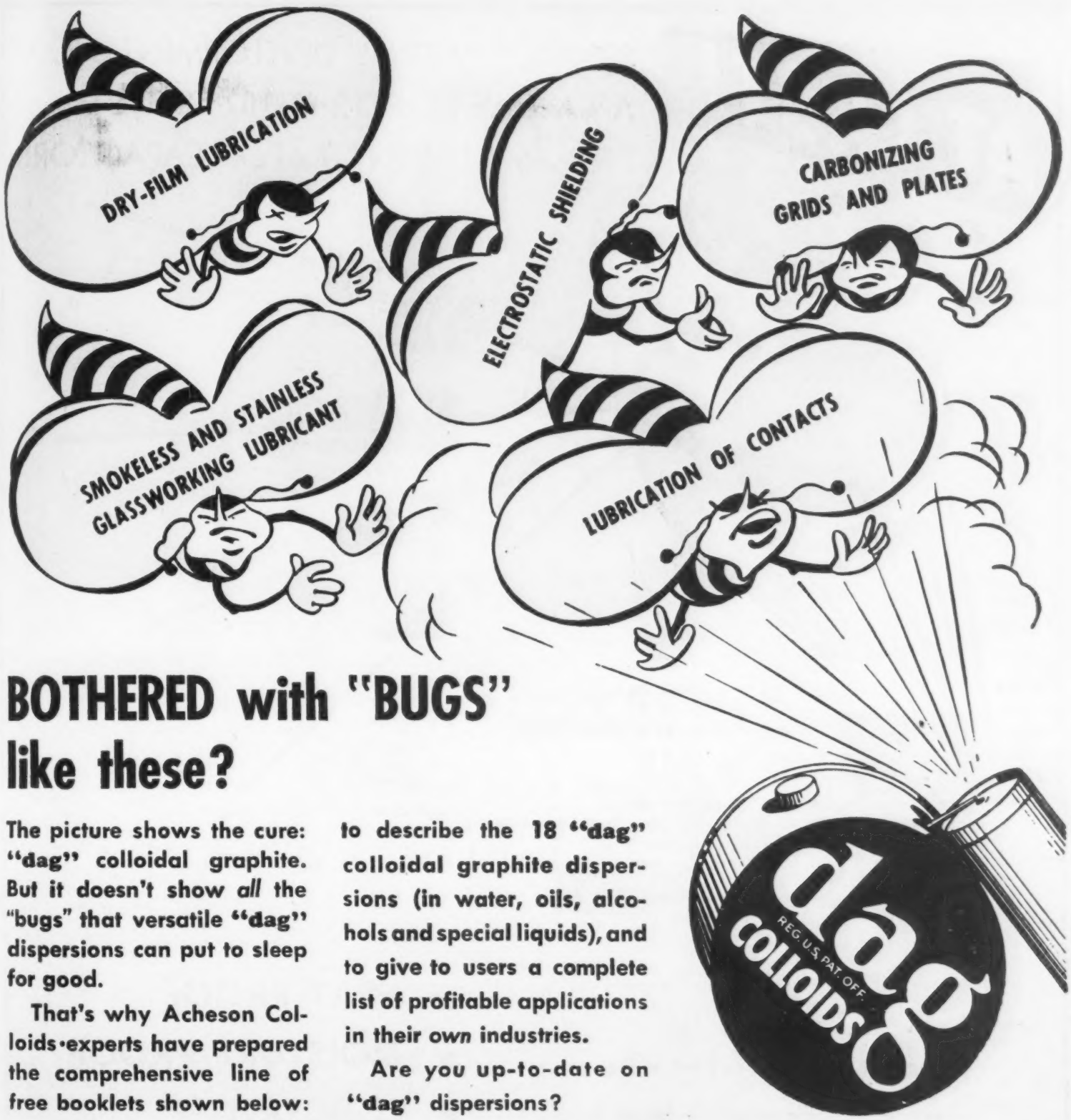
ACCURACY OF COIL CHECKS: May be checked against standard to within about 0.2% with coil values of 10 microhenries to 10 millihenries and Q of 100 or greater.

CAPACITANCE RANGE: Capacitance values ranging between approximately 2-1000 mmf may be checked against a standard to an accuracy of a few tenths of one mmf if the Q of the capacitor is high.

DESIGNERS AND MANUFACTURERS OF
THE "Q" METER . . . QX-CHECKER
FREQUENCY MODULATED SIGNAL GENERATOR
BEAT FREQUENCY GENERATOR
AND OTHER DIRECT READING TEST INSTRUMENTS

BOONTON RADIO *Corporation*

BOONTON·N·J·U·S·A



BOTHERED with "BUGS" like these?

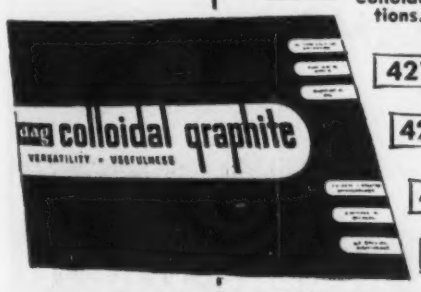
The picture shows the cure: "dag" colloidal graphite. But it doesn't show *all* the "bugs" that versatile "dag" dispersions can put to sleep for good.

That's why Acheson Colloids experts have prepared the comprehensive line of free booklets shown below: to describe the 18 "dag" colloidal graphite dispersions (in water, oils, alcohols and special liquids), and to give to users a complete list of profitable applications in their *own* industries.

Are you up-to-date on "dag" dispersions?

ACHESON COLLOIDS CORPORATION, Port Huron, Michigan

This new literature on "dag" colloidal graphite is yours for the asking:



- 460 — A data and reference booklet regarding "dag" colloidal graphite dispersions and their applications. 16 pages profusely illustrated. ☐
- 421 — Facts about "dag" colloidal graphite for ASSEMBLING AND RUNNING-IN ENGINES AND MACHINERY. ☐
- 422 — Facts about "dag" colloidal graphite as a PARTING COMPOUND. ☐
- 423 — Facts about "dag" colloidal graphite as a HIGH TEMPERATURE LUBRICANT. ☐
- 431 — Facts about "dag" colloidal graphite for IMPREGNATION AND SURFACE COATINGS. ☐
- 432 — Facts about "dag" colloidal graphite in the FIELD OF ELECTRONICS. ☐

ACHESON COLLOIDS CORPORATION
PORT HURON, MICHIGAN DEPT. LL-5

JMLcoALL-1

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OUR PRESENT OIL SUPPLIER IS_____

(Lubricants containing "dag" colloidal graphite are available from major oil companies.)

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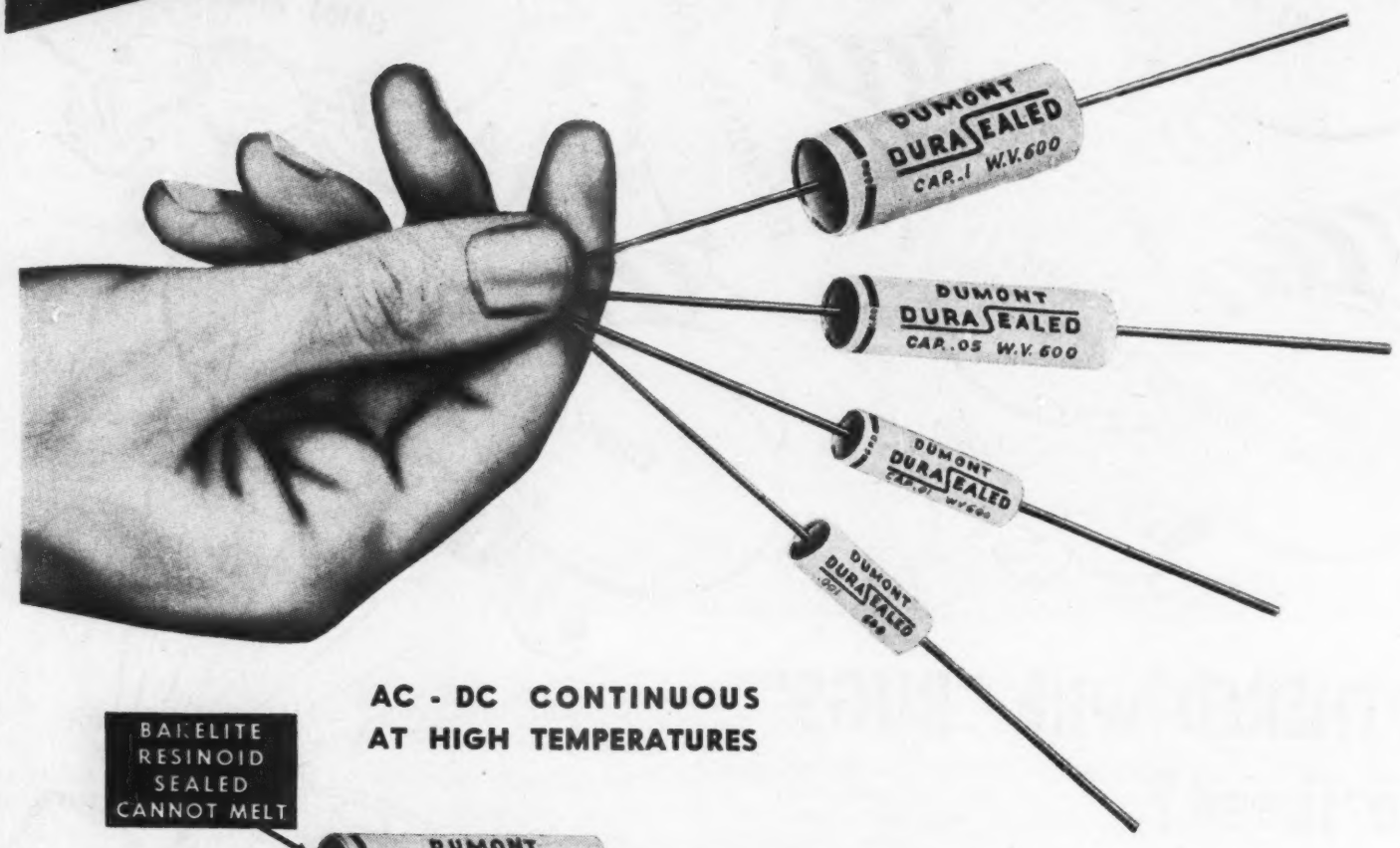
SPECIAL WARTIME DEVELOPMENT NOW AVAILABLE FOR PUBLIC USE . . . TYPE P6 DUMONT *PAPER* CAPACITORS



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BAKELITE RESINOID SEALED CANNOT MELT

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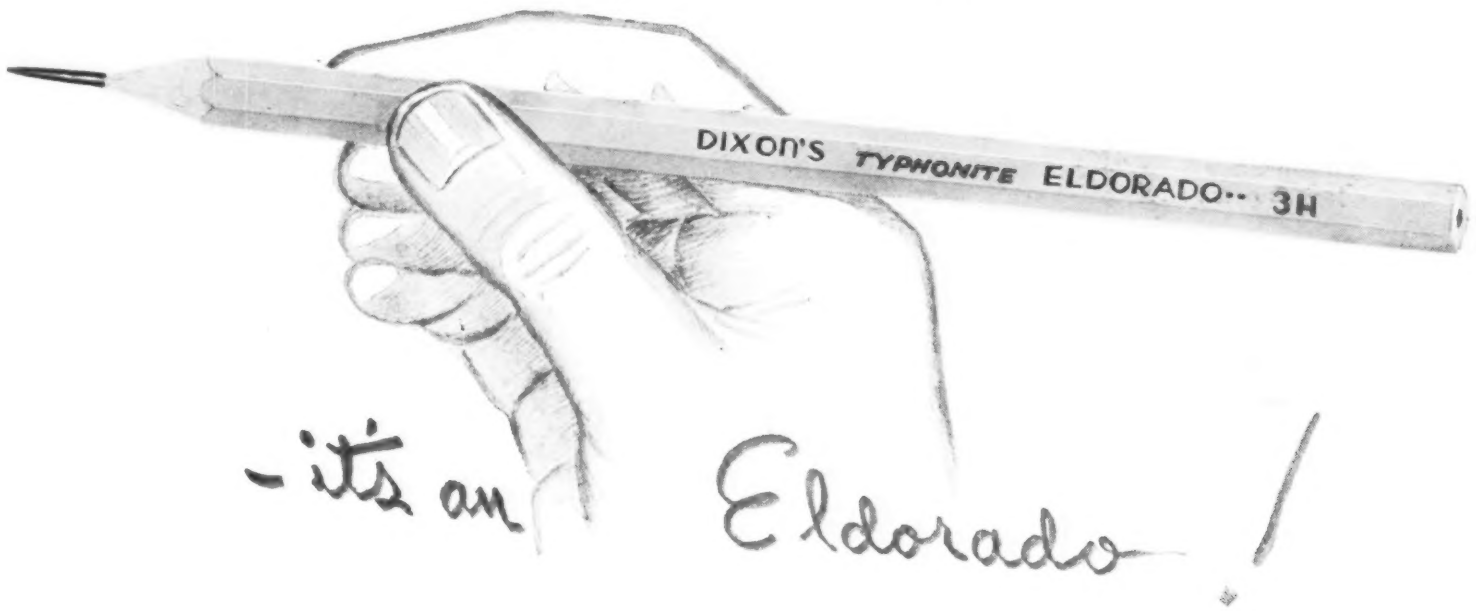
★ Dumont engineers scored in the greatest single achievement in paper tubular capacitors . . . meeting the most exacting requirements. This type P6 has the ends sealed in BAKELITE RESINOID. Leads cannot PULL OUT or MELT OUT. Bakelite treated tubes sealed in vacuum.

★ HEAT PROOF
★ MOISTURE PROOF
★ LONGER LIFE
★ VACUUM SEALED
★ SOLVES SPACE PROBLEMS

DUMONT ELECTRIC CORP.
MFR'S OF CAPACITORS FOR EVERY REQUIREMENT

34 HUBERT STREET
NEW YORK, N. Y.

Expert fingers know—



—it's an Eldorado!

The Easy drafting Pencil Just as a superior instrument responds to the sensitive fingers of a master pianist—so do the true degrees of Typhonite Eldorado leads respond to the skilled fingers of a draftsman. Eldorado is the easy drawing pencil that puts harmony in all work. Let it work for *you!*

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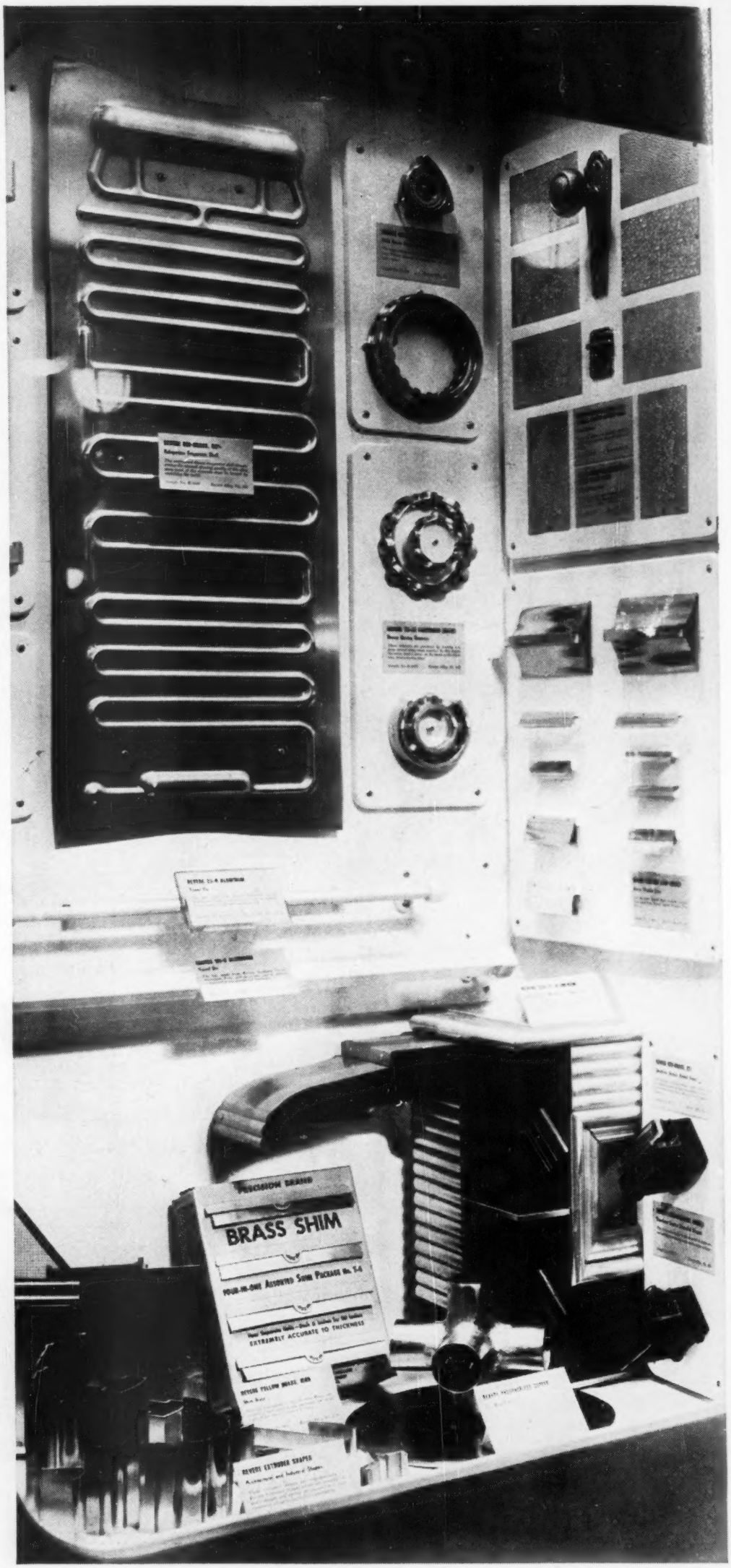
Why there are so many REVERE METALS

THERE are so many Revere Metals because no one metal can possibly fill all requirements. For high electrical and heat conductivity, for example, the coppers are supreme, but where heat conductivity *plus* extra strength is required, as in condensers and heat exchangers, alloys such as cupro-nickel or Admiralty metal may be required. Special corrosive conditions likewise may affect the choice of metal. When weight is a factor, as in anything that must be moved by mechanical or manpower, there are Revere aluminum and magnesium alloys. If fabrication costs are an important element, copper in one of its several types will be selected for some products, free-cutting brass rod for screw machine work, brass sheet and strip for severe forming operations, Herculoy for the corrosion resistance of copper with strength of mild steel plus ready weldability. Seldom, however, is there only one factor to be considered in selecting a Revere Metal; usually there are several, and striking the correct balance may not be easy. In such cases, Revere is glad to offer the cooperation of its Technical Advisory Service.

Revere Metals are offered in the form of mill products, as follows: *Copper and Copper Alloys:* Sheet and Plates, Roll and Strip, Rod and Bar, Tube and Pipe, Extruded Shapes, Forgings. *Aluminum Alloys:* Tube, Extruded Shapes, Forgings. *Magnesium Alloys:* Sheet and Plate, Rod and Bar, Tube, Extruded Shapes, Forgings. *Steel:* Electric Welded Steel Tube.



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DRIVER-HARRIS ALLOY for *Every* *Electrical* Resistance Requirement

NICHROME* & NICHROME V for winding large value resistors where space factors call for compactness in design without sacrificing dependability. Available in all shapes and sizes drawn down to the extremely fine gauge of .001" diameter—67 miles to the pound.

MANGANIN for precision bobbins, Wheatstone Bridges, Decade Resistance Boxes, Potentiometers and National Bureau of Standards type resistance standards which require fixed stability and constant resistance under normally variable operating conditions and negligible thermal e.m.f. against copper.

Also the time-tested standard alloys for all vitreous enamel resistor requirements due to the complete absence of occluded gases. NICHROME V is particularly recommended when a more constant resistance at variable temperatures is specified.

ADVANCE* for winding precision resistors used in electric meters and laboratory testing devices. In finer sizes its negligible temperature co-efficient of resistance (±.00002) combined with high resistivity makes it the most desired alloy for this use.

In addition to these we manufacture over 80 different electrical *heat and corrosion-resistant* alloys. If your resistance requirements are different tell us about them and depend on it... Driver-Harris will develope the alloy best suited to your specifications.

Nichrome is made only by

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BRANCHES: Chicago • Detroit • Cleveland • Los Angeles • San Francisco • Seattle

*Trade Mark Reg. U.S. Pat. Off.

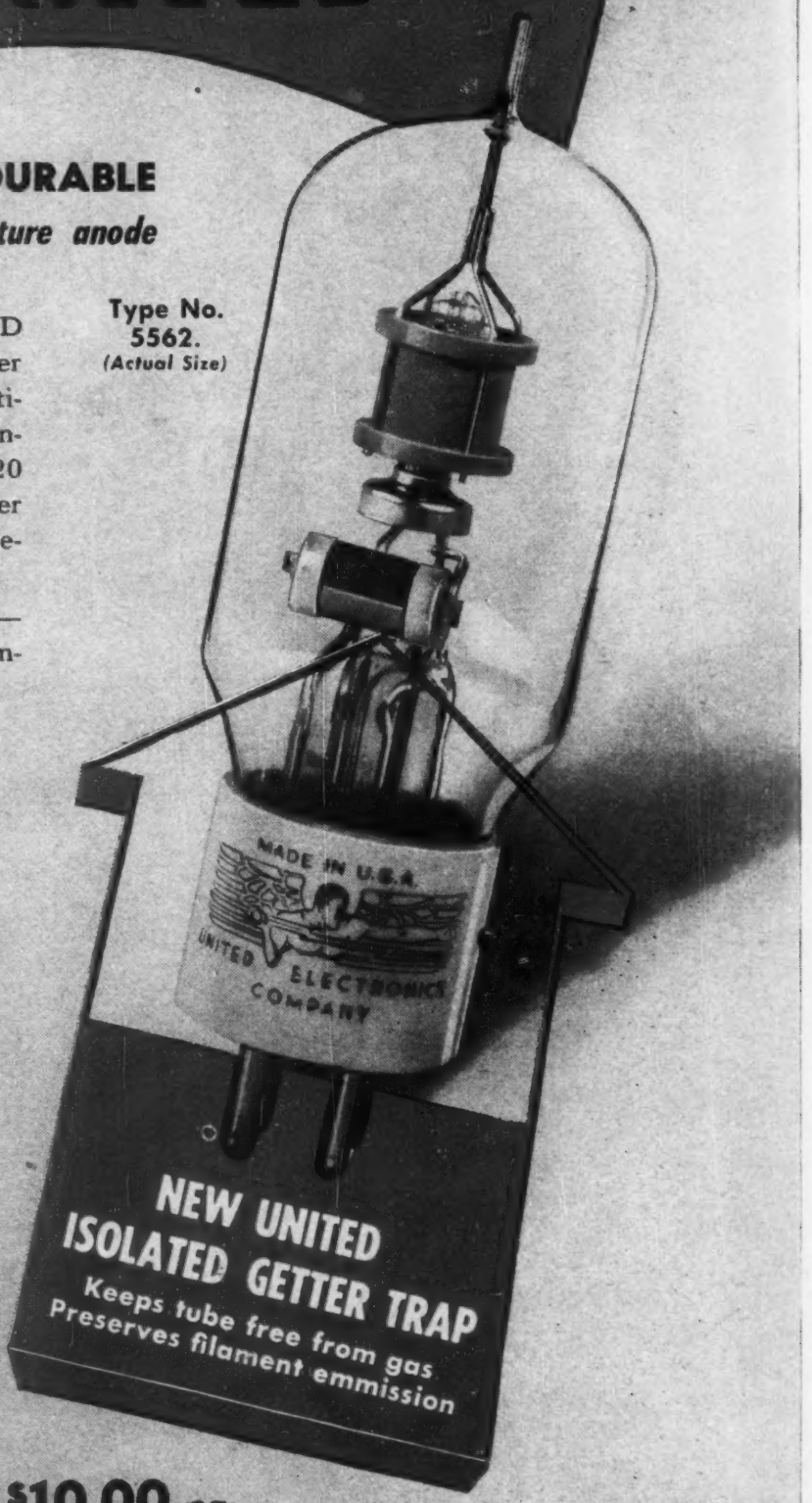
New BEAM TETRODE *by* UNITED

COMPACT • POWERFUL • DURABLE

with graphite, the real low temperature anode

DESIGNED for service longevity, UNITED type 5562 will prove to be a popular number on the VHF bands of the amateur, aeronautical, mobile, and emergency services. Conservatively rated at 175 watts input up to 120 megacycles. Authentic input ratings for higher frequencies will be announced after completion of further factory life tests.

Type 5562 has low drive characteristics—from 2 to 4.5 watts dependent upon plate input, frequency, and class of operation.



Type No. 5562. *(Actual Size)*

GENERAL CHARACTERISTICS		
Filament, 6.3 volts at 3.0 amps.		
Amplification factor	—	60
Transconductance	—	2500 micromhos
Direct Interelectrode capacitances		
Input to plate		.2 mmfds
Input		6.5 mmfds
Output		1.8 mmfds

MAXIMUM RATINGS	Class C Phone	Class C Telegraphy
D.C. Plate Voltage	1250	2000 volts
D.C. Grid Voltage (Grid # 1)	250	350 volts
D.C. Grid Voltage (Grid # 2)	350	400 volts
D.C. Plate Current	100	125 ma
D.C. Grid Current	20	20 ma
Plate Input	125	175 watts
Screen Input	8	8 watts
Plate Dissipation	35	45 watts

UNITED

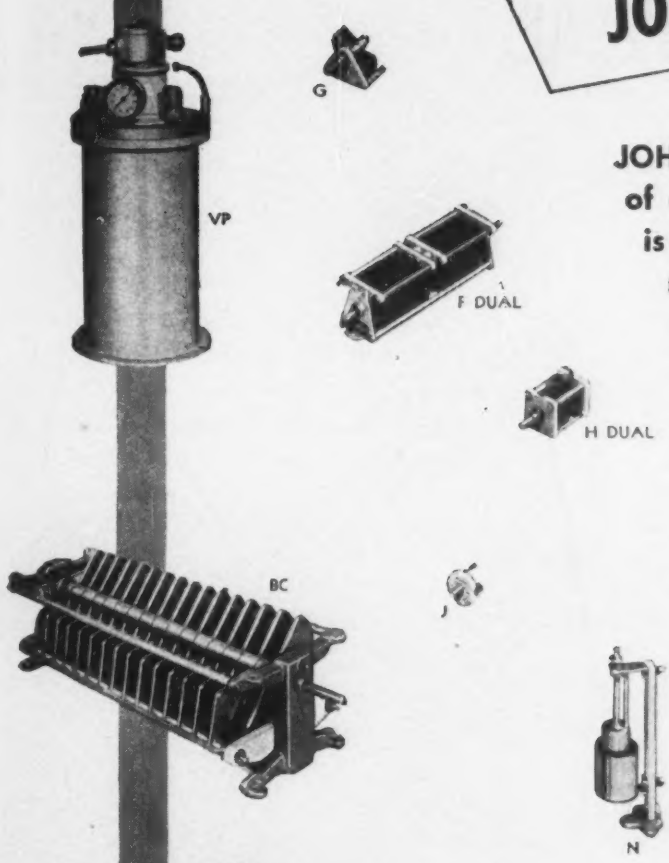
ELECTRONICS COMPANY

NEWARK, 2 NEW JERSEY

$10.00 ea.

Transmitting Tubes EXCLUSIVELY Since 1934

Important advantages are yours with JOHNSON *condensers*



Many evidences of superiority in JOHNSON condensers reflect the twenty-three years of experience that has gone into them. Each type is carefully designed by electronic engineers for maximum circuit efficiency. A primary design objective at JOHNSON'S has been the accomodation of a greater number of specific requirements with a standard condenser or minor modification of a standard. JOHNSON'S search for better design and methods is continuous and employs first class engineering talent and equipment. Many developments, such as the new plate design mentioned below, not only bring increased efficiency but a saving in cost.

JOHNSON offers many standard types from which to choose with capacities to 10,000 mmf, voltage ratings to 30,000. See your distributor or write to Dept. D today.

Plates for types A and B condensers are of the new heavy rounded edge design recently developed by JOHNSON engineers. Their higher breakdown voltage permits closer spacing, a shorter condenser, lower minimum, and less inductance at U H F. These features combined with new end frame design reduce weight to minimum, yet cost no more, in most cases less because of the saving in material.

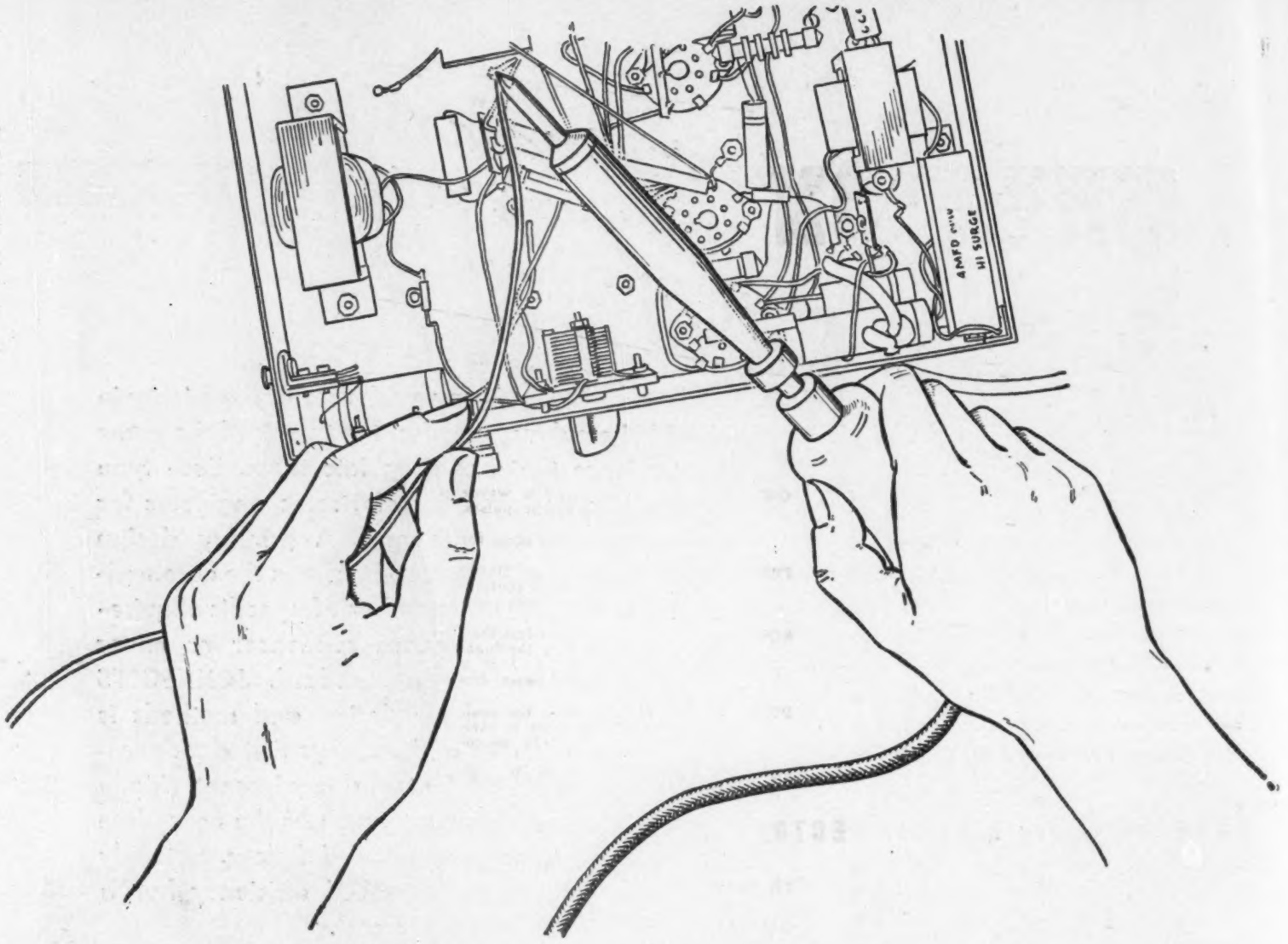
JOHNSON
a famous name in Radio

Johnson products include

Condensers	Inductors	Sockets
R. F. Chokes	Q Antennas	Insulators
Connectors	Plugs & Jacks	Hardware
Pilot and Dial Lights	Broadcast Components	
Directional Antenna Equipment		

E. F. JOHNSON CO., WASECA, MINNESOTA

LET BENTLEY, HARRIS WAR-TIME RESEARCH PAY DIVIDENDS FOR YOU TODAY.



Soldering irons require an insulation of high dielectric strength that can stand temperatures up to 1200° F.—will not react to heat conducted through wire. Read the results obtained by a manufacturer who put this problem up to Bentley, Harris:

"We tested BH Fiberglas Sleeving in our soldering irons for over 1,000 hours of continuous duty, heating and cooling over 2,000 times. The results were entirely satisfactory without any defect in heat resistance or in required dielectric strengths."

Test BH Fiberglas Sleeving in your own plant, in your own product—under actual service conditions. Compare it with ordinary saturated sleeving. See how it remains flexible as string and non-fraying. Learn why America's leading makers of home appliances, radios and industrial equipment have standardized on BH Fiberglas Sleevings in their plans for post-war production.

BENTLEY, HARRIS MFG. CO., CONSHOHOCKEN, PA.

BH Fiberglas* SLEEVINGS

*BH Non-Fraying Fiberglas Sleevings are made by an exclusive Bentley, Harris process (U. S. Pat. No. 2393530). "Fiberglas" is Reg. TM of Owens-Corning Fiberglas Corp.

USE COUPON NOW

Bentley, Harris Mfg. Co., Dept. E-4, Conshohocken, Pa.

I am interested in BH Non-Fraying Fiberglas Sleeving for_____ (product)

operating at temperatures of ____°F. at ____ volts. Send samples so I can see for myself how BH Non-Fraying Fiberglas Sleeving stays flexible as string, will not crack or split when bent.

NAME_____ COMPANY_____

ADDRESS_____

Send samples and prices on other BH Products as follows:

- ☐ Magneto Varnished Tubing Grade "A"
- ☐ Flexible Varnished Tubing Grade "B"
- ☐ Saturated Sleeving Grade C-1
- ☐ Saturated Sleeving Grade C-2
- ☐ Saturated Sleeving Grade C-3

NOW READY: 3 NEW MODELS

SHERRON *Quality* LABORATORY INSTRUMENTS

SHERRON MULTIWAVE SHAPE GENERATOR

Designed to serve as a source of several wave shapes, and will prove very useful in the testing of amplifiers and associated equipment at audio and video frequencies. A regulated power supply is incorporated, which supplies plate and screen voltages for all stages.

SPECIFICATIONS:

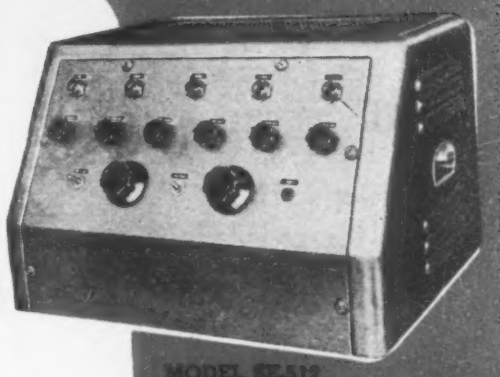
OUTPUTS—Sine waves, square waves, positive pulses, negative pulses, and a trigger pulse. Impedance (output) 250 ohms for all voltages.

FREQ. RANGE—50 cycles to 50,000 cycles for all voltages continuously variable with a direct reading dial.

SQUARE WAVE—Rise time is less than .3 of a micro-second at the highest frequency and about .7 of a micro-second at the lowest frequency.

PULSES—Pulse width of both the positive and negative outputs is variable from about 1 to 75 micro-seconds.

POWER REQUIREMENTS—115 V., 60 cycle, 300 watts.



MODEL SE-512

SHERRON R.F. NULL DETECTOR

Visual indications permit this unit to be operated in noisy locations where aural indications may be useless. May be used as a signal generator to provide power at 1 MC, or as a sensitive detector at the same frequency. Both generator and detector are housed in the same cabinet.

SPECIFICATIONS:

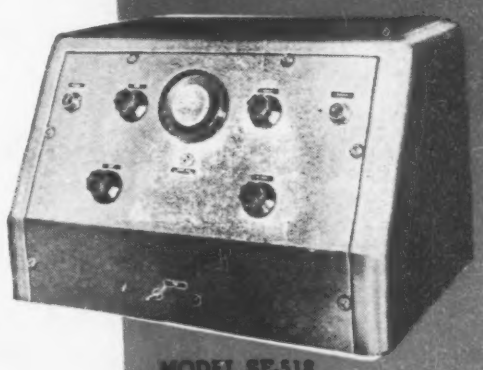
FREQUENCY
1 MC

GENERATOR OUTPUT
0-5 volts

DETECTOR GAIN
500,000 plus

HARMONIC SUPPRESSION
2nd down more than 100 db

POWER REQUIREMENTS
115 volts, 60 cycle, 120 watts



MODEL SE-518

SHERRON D.C. VACUUM TUBE VOLTMETER-MICROAMMETER

Measures minute direct current and voltages on a new and different principle—a vast improvement over conventional methods. Converts electronically, the D.C. voltage to be measured to alternating voltages of a fixed frequency—amplifies, and then meters. An instrument of extremely high sensitivity. Can also be used as a megohmmeter with external voltage source.

SPECIFICATIONS:

VOLTMETER

RANGES—.015, .05, .15, .5, 1.5, 5, 15, 50, 150, 500, 1500 volts full scale.

INPUT IMPEDANCE—1 megohm on all ranges with exception of 1500V scale, where the impedance is 3 megohms. This gives a sensitivity of 68 megohms/volt on the lowest range.

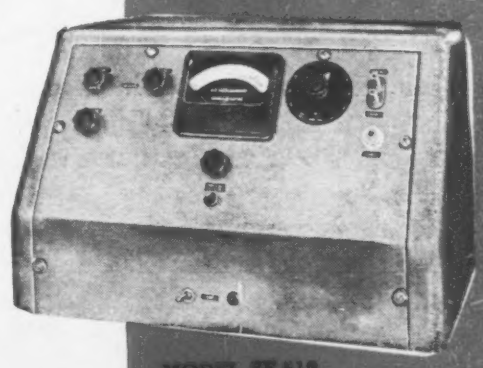
MICROAMMETER

RANGES—.015, .05, .15, .5, 1.5, 5, 15, 50, 150, 500 microamps full scale.

VOLTAGE DROP—Maximum .15 volts. On lower ranges it drops to .045 volts.

OHMMETER: Resistance can be determined by measuring E & I from any external power supply. With 500 volts, 67,000 megohms, gives half scale reading on maximum range.

POWER REQUIREMENTS: 115 volts, 60 cycle, 175 watts.



MODEL SE-519

Sherron Electronics W2XDK

SHERRON ELECTRONICS COMPANY

Division of Sherron Metallic Corporation

1201 FLUSHING AVENUE, BROOKLYN 6, NEW YORK

West Coast Sales Office: MECHANICS INSTITUTE BLDG., 57 Post St., San Francisco, Calif.

NEW EDITION OF FIBERGLAS ELECTRICAL INSULATION MATERIALS CATALOG

Just off the Press

Anyone concerned with insulation for electrical, radio, electronic or video applications can use the Fiberglas Electrical Insulation Materials Catalog to advantage.

It contains complete information about the many forms of Fiberglas Electrical Insulation Materials. Indicates where and how to use this material to obtain its many advantages.

It describes the unique combination of electrically and mechanically important characteristics of Fiberglas, such as: resistance to high temperature, moisture and acid; favorable space factor and high tensile strength. It shows how the insulating impregnants increase the effectiveness of Fiberglas' inherent characteristics and add others such as high dielectric strength, insulation resistance and resistance to abrasion.

You will see why the use of this basic, inorganic, insulating material is increasing so rapidly—*why the swing is to Fiberglas.*

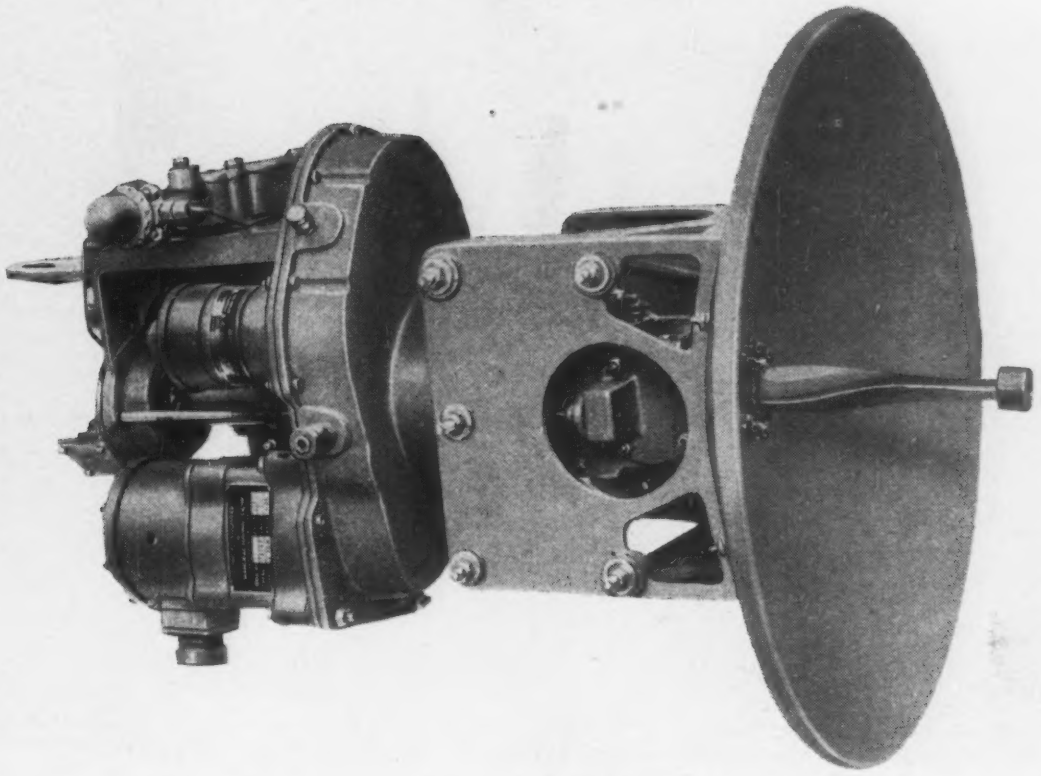
Be sure to have a copy of this new booklet in your file for ready reference. Write for copy today —there is no obligation. Owens-Corning Fiberglas Corporation, Dept. 860, Toledo 1, Ohio.

In Canada, Fiberglas Canada Ltd., Toronto, Ontario.

OWENS-CORNING

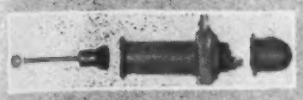
FIBERGLAS

AIRCRAFT RADAR ANTENNA TYPE AN/APS-6



At the close of hostilities Dalmo-Victor was producing and delivering nearly 90% of the night fighter Radar Antenna-Scanners used by the U. S. Navy. We had developed the top quality product in this field.

Our "know-how" is ready for commercial and research development purposes, our engineering and electronic research staff is intact, our manufacturing and testing facilities are ample. We solicit inquiries from electronic engineers, aircraft companies — from all who may be properly interested.

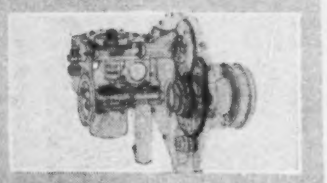


APS 6 AIR PUMP

The Dalmo-Victor designed air pump is a slow-speed, single-action piston pump, which requires no extra power source. Air is delivered to rear joint of the antenna wave guide, and will maintain a pressure of 10 pounds per square inch gauge at all altitudes up to 30,000' above sea level against an air leakage of 4 cubic inches of free air per minute.

FEED HORN

This feed is a pressurized X-Band rearward directing feed horn for circular paraboloids. The electrical features include high gain, low VSWR, and external tuning adjustment. The mechanical features include 100 per cent pressure tight sealing, light weight, few parts, and ease of fabrication and assembly.



MAIN GEAR HOUSING

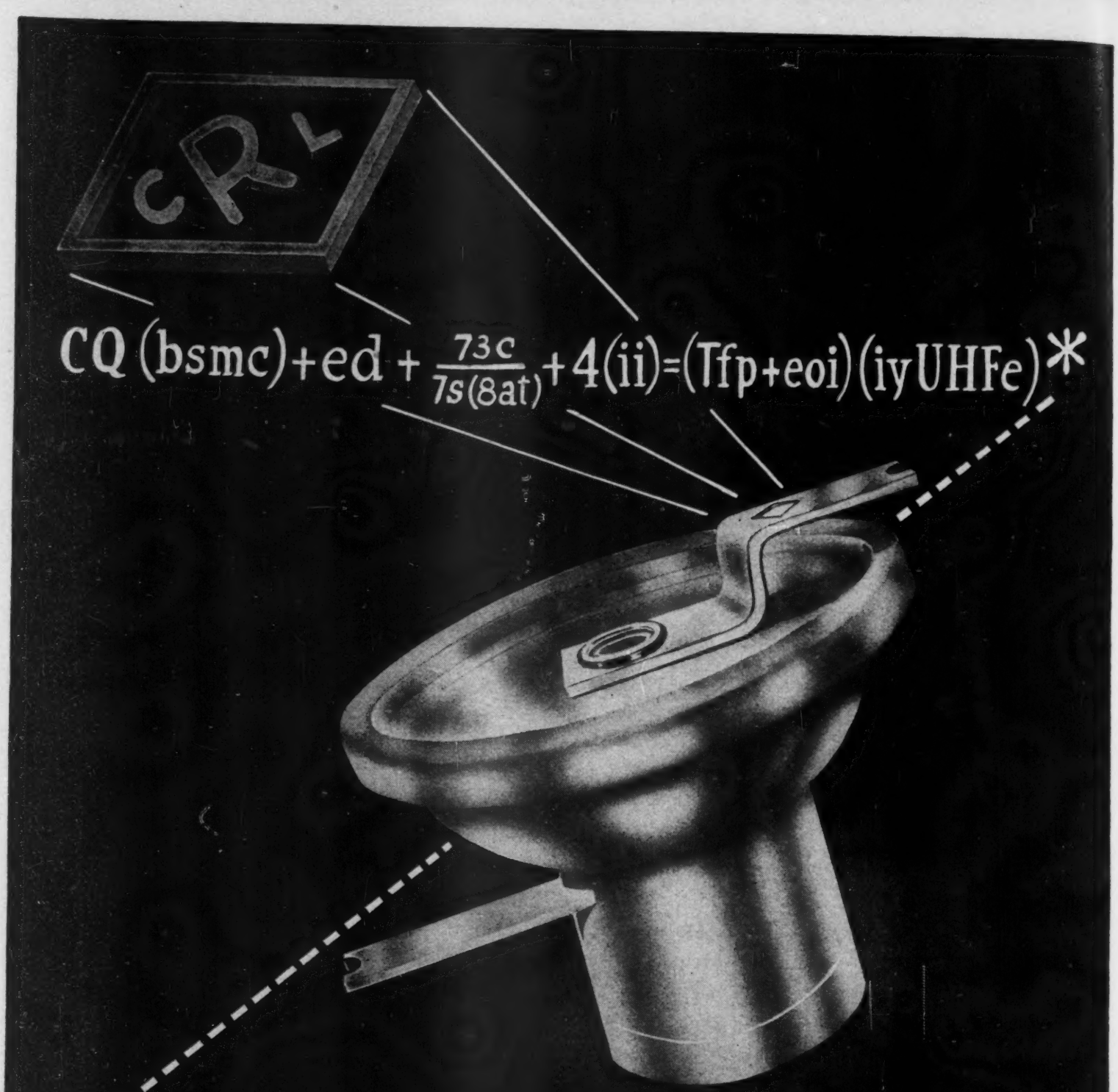
The AN/APS-6 Antenna is a high-speed spiral type of scanner driven at 1200 r.p.m. through enclosed helical gearing, and simultaneous nod motion is introduced by means of a crank reciprocated rack and pinion mechanism to impart a nod motion of ± 60° at a rate of 15 complete nod cycles per minute.

APS/6 GENERATOR

Dalmo Victor developed this 2 phase, 20 cycle generator for use on the AN-APS/6 Antenna, using a permanent magnet type rotor and to develop 67 volts r.m.s. at 1200 r.p.m. Total harmonic content does not exceed 5%. Simplicity of construction makes possible ease of assembly and phasing.

DALMO VICTOR

SAN CARLOS, CALIFORNIA



*CENTRALAB Quality button silver mica capacitors + early delivery + 73 combinations made up of 7 styles with 8 available terminals + 4 individual inspections (capacitance, power factor, voltage breakdown and leakage resistance) = Trouble free performance and ease of installation in your Ultra High Frequency equipment.

Send for Bulletin 586

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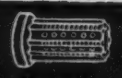
Division of GLOBE-UNION INC., Milwaukee

PRODUCERS OF

Silver Mica Capacitors
Bulletin 630


Ceramics
Bulletin 720

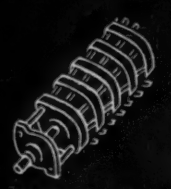
Ceramic High Voltage Capacitors
Bulletin 630

Ceramic Trimmers
Bulletin 630

Radiohms
Bulletin 697

Tubular Ceramic
Capacitors
Bulletin 630

Ceramic Plate Capacitors
Bulletin 630

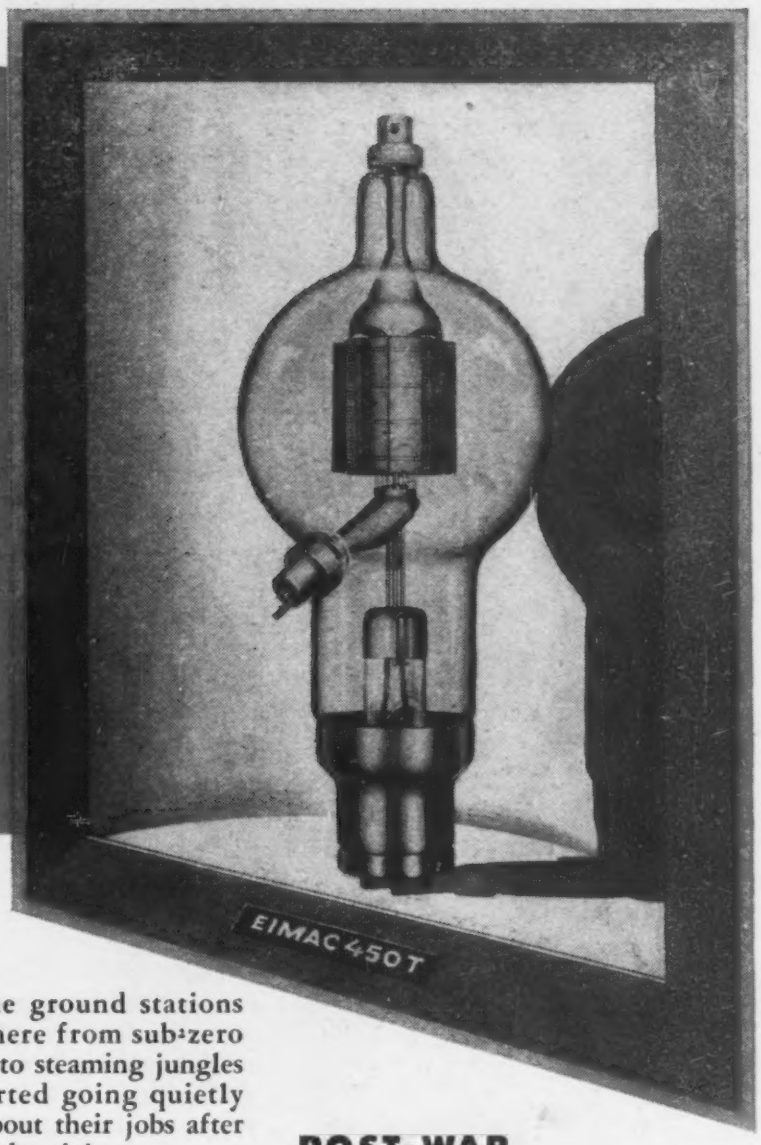

Selector Switches
Bulletin 722

FOR AN HONORED PLACE IN THE HALL OF FAME

Perhaps no other single transmitting tube has such a great and rightful claim to fame as has the Eimac 450T triode.

This tube, one of the original members of the Eimac family, has consistently established records for plus performance in some of the world's most gruelling applications.

Long before the war the Eimac 450T established a high standard of dependability and performance in the ground stations of leading commercial airlines. Because of their outstanding dependability and inherently superior capabilities, these tubes were snapped up for wartime duty in many vital applications.

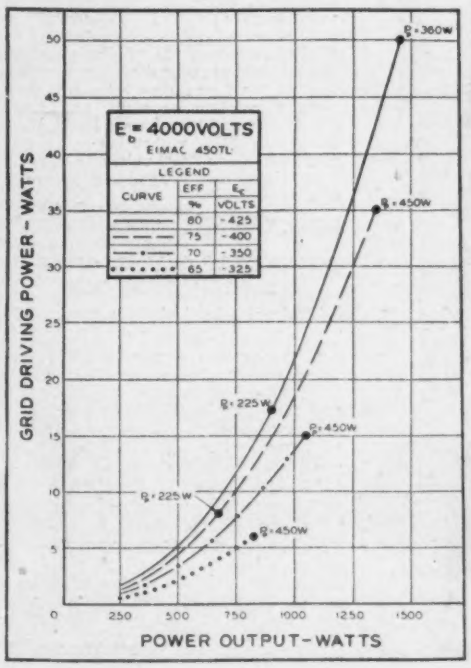


UNUSUAL VERSATILITY

The Eimac 450T is perfectly suited to a wide variety of uses as a modulator, oscillator, or amplifier. It is available as a high-mu (450TH) or low-mu (450TL) type. In every capacity, the Eimac 450T is tops in its power range; stable, rugged, and above all, proven over years of successful use.

LONG DEPENDABLE LIFE

When the first Eimac 450T's were installed in several major broadcasting stations, operators consistently reported better than 15,000 hours of service, top-notch performance. They were astounded to see such a compact tube do a giant's job. Eimac 450T's in airline ground stations located everywhere from sub-zero mountain passes to steaming jungles have been reported going quietly and efficiently about their jobs after 20,000 hours on the air!



PERFORMANCE PLUS

Performance is, after all, the ultimate criterion of electron tubes. The unusual capabilities and low interelectrode capacitances of the Eimac 450T are two of the reasons for its widespread use in 1 Kw to 5 Kw stations at frequencies up to 60 Mc. And even at frequencies up to 150 Mc, the 450T triode will provide a useful output.

HIGH POWER-GAIN

In a class B audio amplifier, a pair of Eimac 450TL's will provide 2200 watts plate power output with a driving power of but 15 watts! Or, in a class-C application, a *single* Eimac 450TL will provide an r-f plate power output of 1800 watts with but 42 watts driving power.

POST-WAR IMPROVEMENTS

The 450T, proven before war and during war, stands today as a greater tube than ever before. Post-war developments, the result of steady, intensive research in Eimac's laboratory, has brought to today's 450T new electrodes for higher thermionic efficiencies and even longer life.

With these facts in mind, it's easy to see why the Eimac 450T is accepted over any other triode of like rating. This veteran tube has stood the acid test of time and rugged duty around the world. Today a still better 450T awaits your order. Inquire!

EITEL-McCULLOUGH, INC.
1305E San Mateo Ave., San Bruno, Calif.

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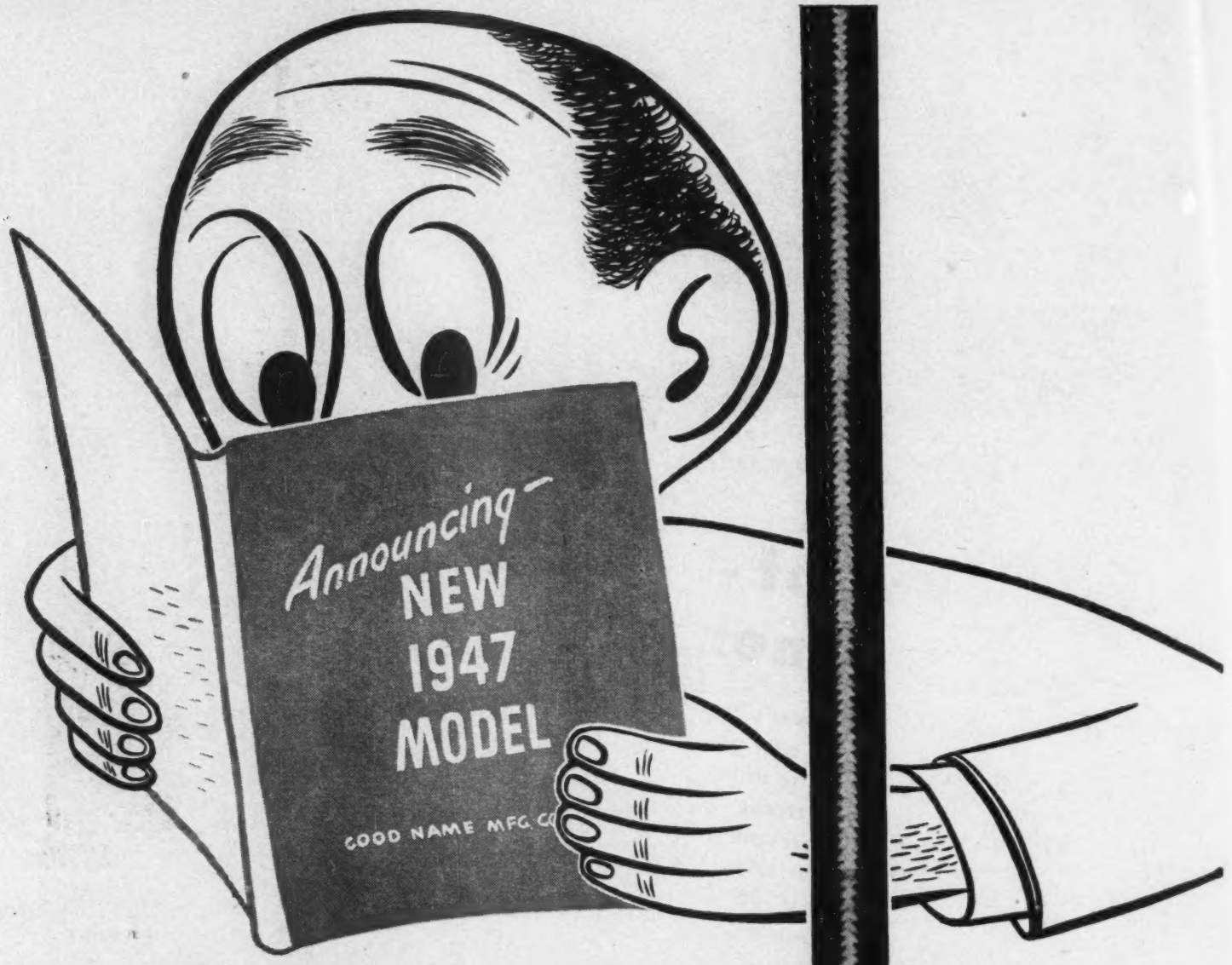
Follow the Leaders to Eimac REG. U.S. PAT. OFF. TUBES

THE COUNTERSIGN OF DEPENDABILITY IN ANY ELECTRONIC EQUIPMENT



WRONG WIRING CAN WRECK IT

No matter how carefully you plan, it's hard to determine just how well your new product is going to perform in actual service. But you *are* in a position to know whether it generates heat that may bake out and crack the insulation of the wiring or cause it to flow. And you can also anticipate whether it will be used in hot places where high ambient temperatures could have similar harmful effects on the wiring. Or whether it will be subject to attack by corrosive fumes, oil or grease.

In all such cases *permanently* insulated wiring is a *must*. And the name to remember for complete assurance of *permanence* is Rockbestos. Each of the 125 wires, cables and cords in this time-tested line was developed to outlast the products in which they are installed. Write for catalog or recommendations.

ROCKBESTOS PRODUCTS CORPORATION, 441 NICOLL ST., NEW HAVEN 4, CONN.

ROCKBESTOS

The Wire with Permanent Insulation

NEW YORK BUFFALO CLEVELAND CHICAGO PITTSBURGH ST. LOUIS LOS ANGELES SEATTLE SAN FRANCISCO PORTLAND, ORE.

Permanently Insulated Wiring Insures Your Product's Performance

The large cable illustrated to the left is Rockbestos A.V.C. Motor Lead and Apparatus Cable. Insulated with asbestos and varnished cambric, and covered with a heavy asbestos braid, it is made in sizes 18 AWG to 2,000,000 CM.

Rockbestos Firewall Hookup Wire

This heat, flame and moisture resistant wire, insulated with high dielectric tapes and impregnated felted asbestos and covered with color-coded lacquered glass braid, has a maximum operating temperature of 125° C. Ideal for radios, television, amplifiers, calculators or small motor, coil, dynamotor and transformer leads. No. 22 to 4 AWG in 1000 volt rating — No. 12, 14 and 16 AWG in 3,000 volt, also in twisted pair, tripled, shielded and multi-conductor constructions.

ROCKBESTOS A. V. C. 600 VOLT SWITCHBOARD WIRE

(*National Electrical Code Type AVB*)

This wire was designed to make complicated wiring jobs permanent. The impregnated felted asbestos wall beneath the flameproofed cotton braid is heat, flame and moisture resistant and assures fine appearance of boards as it gives on bends to prevent braid cracking. Sizes 18 to 4/0 AWG with solid or stranded conductors in black, grey, or colors. Rockbestos A.V.C. Hinge and Bus Cable have the same characteristics.

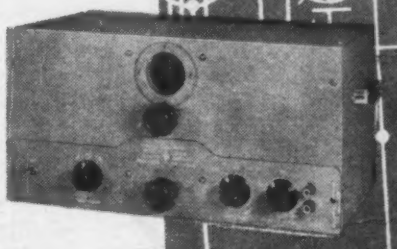
These are but a few of the 125 different permanently insulated wires, cables and cords designed by Rockbestos to meet severe or unusual operating conditions.

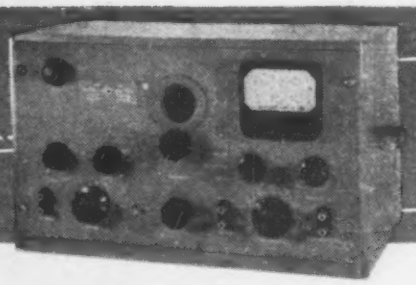
hp LABORATORY INSTRUMENTS FOR SPEED AND ACCURACY

201B AF OSCILLATOR

Meets every requirement for speed, ease of operation, accuracy and purity of wave form in FM and other fields where high fidelity is important.

Frequency range from 20 Cps to 20 Kc. Up to 3 watts power into 600 ohm resistive load with distortion of less than 1%. (Distortion not more than ½% at 1 watt output.) Frequency control is accurately obtained by direct or a 6-1 vernier tuning over a large illuminated, no-parallax dial. Price $190.00 FOB Palo Alto.





330B DISTORTION ANALYZER

Unusually valuable for measurement through the audio spectrum in broadcast, laboratory or production problems. Measures "total" distortion at any frequency from 20 Cps to 20,000 Cps, and will accurately make noise measurement of voltages as small as 100 microvolts. Linear r-f detector makes possible measurement direct from modulated r-f carrier. May be used as voltmeter for measuring voltage level, power output, amplifier gain; or serves as high-gain, wide-band stabilized amplifier with maximum gain of 75 db. Price $375.00 FOB Palo Alto.

One year of -hp- achievement

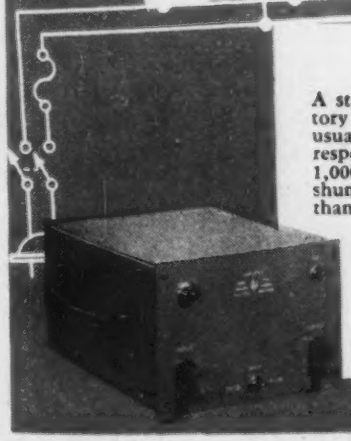
In one single year since the war's end, *-hp-* has brought you five important new precision instruments. All are now in use in laboratories, factories, electrical and electronic installations around the world. Each represents a vital contribution to the field of electrical measurement. Each is an example of how *-hp-* engineering anticipates the rapid strides of modern science.

Soon *-hp-* will announce significant new instruments to further broaden the field of electrical measurement. Meantime we are now able to make immediate delivery on most *-hp-* instruments. Send your order now!

HEWLETT-PACKARD COMPANY
1304A PAGE MILL ROAD • PALO ALTO, CALIFORNIA

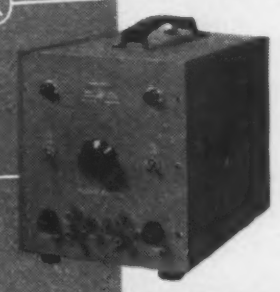
410A VACUUM TUBE VOLTMETER

Measures voltage over wide frequency range (from audio to microwave regions) at high impedance. High input impedance and low shunt capacity makes possible testing video and VHF amplifier circuits without disturbing circuit under test. *ac measurements:* Six ranges, full-scale readings from 1 to 300 volts. Input impedance 6 megohms in parallel with 1.3 *uu*fd. Frequency response 20 Cps to 700 Mc, ±1 db. *dc measurements:* Seven ranges, full-scale readings from 1 to 1000 volts. Input impedance 100 megohms, all ranges. *Resistance measurements:* Seven ranges, mid-scale readings, 10 ohms to 10 megohms. Price $210.00 FOB Palo Alto.



450A AMPLIFIER

A stable, wide-band, general purpose laboratory instrument. 40 db or 20 db gain of unusual stability, low phase shift. Frequency response flat within ½ db between 10 and 1,000,000 cycles. Input impedance 1 megohm shunted by 15 *uu*fd. Internal impedance less than 150 ohms over entire range. Fully operated from 115 volts, 60 cycles AC power supply. Can be used with 400A Vacuum Tube Voltmeter to measure voltages as low as 50 microvolts. Price $125.00 FOB Palo Alto.

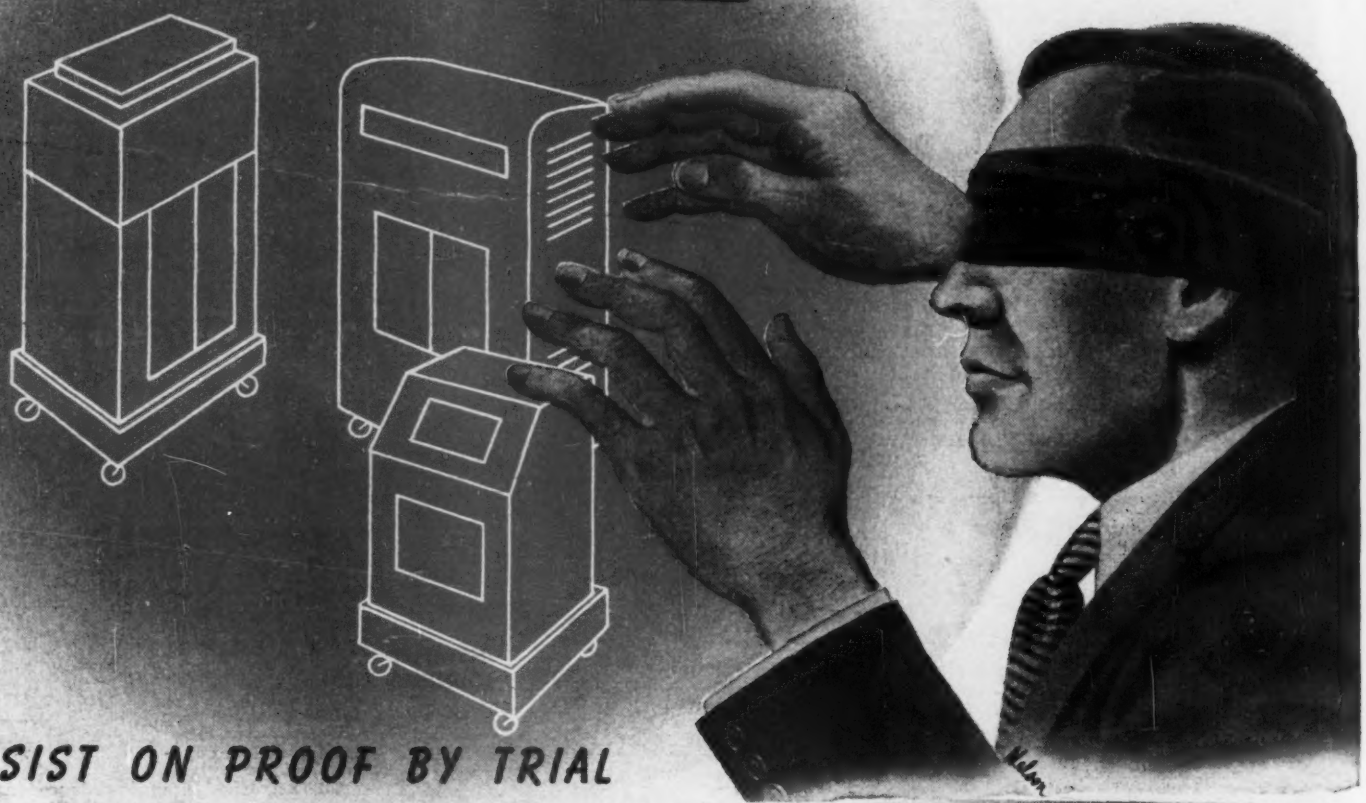


710A POWER SUPPLY

Ideal power supply for general, laboratory, or production use. Delivers any required voltage between 180 and 360 volts, with approximately 1% variation for output currents of from 0 to 75 ma. Maximum current 100 ma. Line voltage variation of ±10% causes less than 1% change in output voltage. Total noise and hum output is less than .005 volts. Supplies up to 5 amps at 6.3 volts ac for heating filaments. Either positive or negative terminal may be grounded. Price $75.00 FOB Palo Alto.

Power Supplies • Frequency Standards • Amplifiers • Electronic Tachometers
Frequency Meters • UHF Signal Generators • Square Wave Generators
hp
Noise and Distortion Analyzers • Audio Signal Generators • Attenuators
Audio Frequency Oscillators • Wave Analyzers • Vacuum Tube Voltmeters

Don't buy an electronic heater *blindly*



INSIST ON PROOF BY TRIAL

Do you do soldering, brazing, surface-hardening, annealing or other heat-treating operations? Or do you use heat to treat non-metallic substances such as plastics, plywood, rubber, etc.?

It is quite possible that you can use electronic heating apparatus for these operations, profitably replacing older and slower heating methods. The savings and increased efficiency are decidedly worthwhile. The speed-up in production is as great as 700% in some instances. Work that formerly took minutes or hours now requires only SECONDS.

Investigate the possibilities of high frequency heating for your production. But be sure and get plenty of sound experienced advice before you buy. Don't just buy a "machine." Let our engineers prove to you by actual demonstration under your own conditions, how Scientific Electric equipment fits your exact needs. Remember, there is no such thing as an all-purpose electronic heater. Each individual operation and each factory production set-up requires a specific type of installation, with the proper combination of frequency and power output. Consult us without obligation. We will engineer the right installation to your particular requirement. Buy nothing till we've PROVED IT BY TRIAL for you.

Scientific Electric Electronic Heaters are made in the following range of power; 3—5—7½—8—10—12½—15—18—25—40—60—80—100—250 KW — and range of frequency up to 300 Megacycles depending on power required.

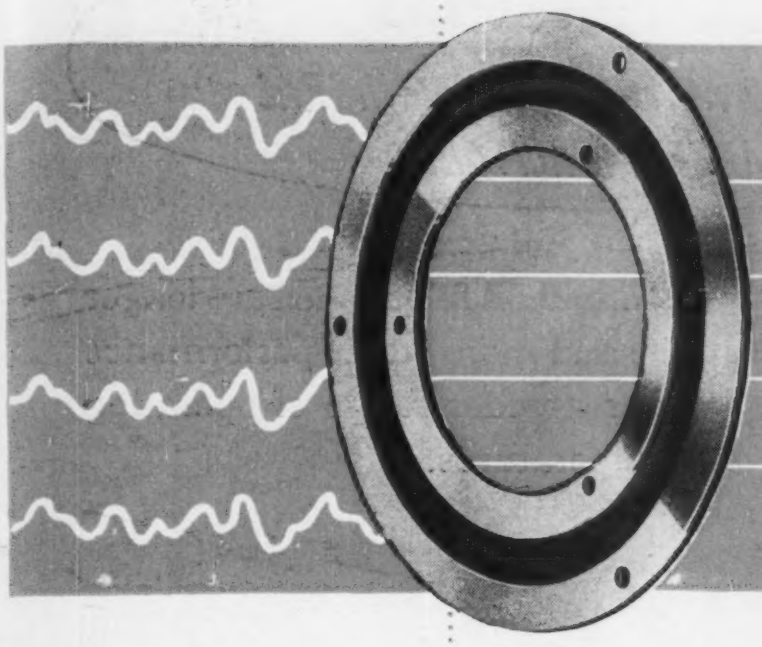
Scientific Electric

DIVISION OF
[illegible] Garfield, N. J.

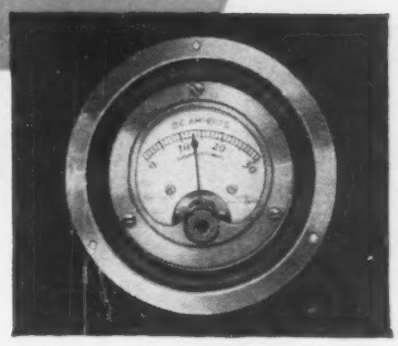
ISOLATED IN A LITTLE WORLD ALL ITS OWN

. . . with

LORD
SHEAR TYPE
Bonded Rubber
MOUNTINGS



INDIVIDUAL METER MOUNTING

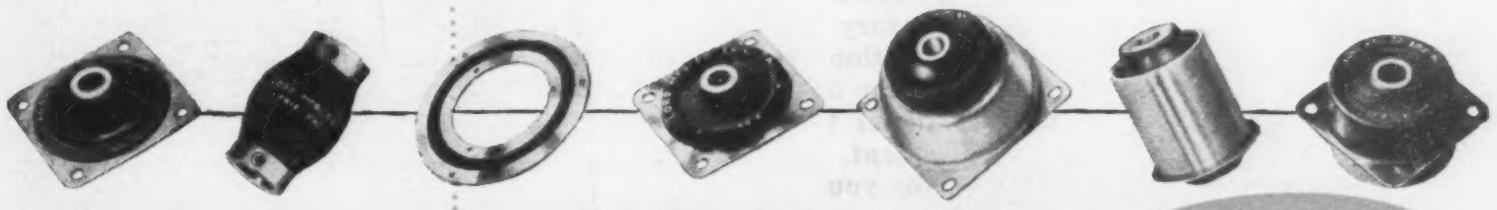


METER INSTALLED WITH MOUNTING

AN accurate meter is a sensitive mechanism, and a sensitive mechanism is also a delicate mechanism. It can't stand the buffetings of vibration, and continue its normal functioning. Yet some of the most important services that meters render must be rendered in the midst of chaotic disturbances.

The Lord Meter Mount creates a new environment, an environment of peace and quiet in the midst of turbulent vibration, for the sensitive and delicate instrument, a little world of its own that is limited by the soft circular cushion of rubber that surrounds it. It goes on quietly registering speed, or altitude, or temperature, or amperes, with self-possessed efficiency.

In a generation of pioneering vibration control we have solved thousands of vibration problems which have come to us. The problem which is new to you may be old to us, with the data in our files and the product in our line to meet it. If it's a new problem, remember that every problem was new when we started. We'll find a solution, and if necessary we'll make a new product to put it into effect.



Every genuine Lord Mounting carries the name "LORD" embossed in the rubber or in raised letters on the forgings.

IT TAKES **BONDED RUBBER** *In Shear* **TO ABSORB VIBRATION**

LORD MANUFACTURING COMPANY
ERIE, PENNSYLVANIA

SALES REPRESENTATIVES
NEW YORK - - 280 MADISON AVE.
CHICAGO - 520 N. MICHIGAN AVE.
DETROIT - - 7310 WOODWARD AVE.
BURBANK, CAL. - 245 E. OLIVE AVE.
CANADIAN REPRESENTATIVES
RAILWAY & POWER ENGINEERING CORP., LTD.
TORONTO, CANADA

Originators of Shear Type Bonded Rubber Mountings

JACK OF ALL TRADES*

SANGAMO METAL-CASED MINERAL OIL PAPER CAPACITORS

Mineral oil filled to assure longer life and more stable performance over a wider range of operating temperatures.

*A Sangamo Capacitor that will fill your needs

Sangamo Types 20 and 21 Capacitors have attained extreme popularity with their users because of their excellent by-pass and coupling qualities. Vacuum impregnated and filled with the highest grade of mineral oil, their capacity is stable from 55°C below to 85°C above zero. Capacitors are available within the range of 200 to 2000 volts working.

Write for the new Sangamo Capacitor Catalog which contains complete information for your use

SANGAMO ELECTRIC COMPANY
SPRINGFIELD • ILLINOIS

GOOD COMPANY

WE'RE not pretending we belong in any Gallery of the Great. It's just our way of calling attention to the fact that a manufacturing organization, as well as a famous personage, can have character and individuality.

Through the years the Karp organization has become known as a good company to do business with—a company with a likeable personality—a company that understands and practices cooperative service.

Because our experience and craftsmanship in sheet metal fabrication mean good business for our customers, our services are preferred by many of the "great names" in American industry. We're extremely proud of the outstanding firms we serve.

They like our work. They like the sound value our work represents. They find their relations with us helpful and pleasing.

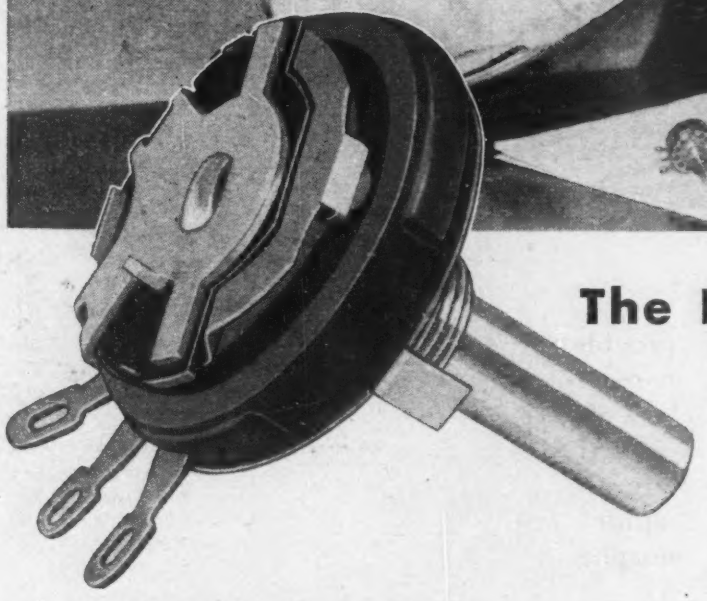
If you are not already on our list of customers, let's get acquainted. Consult us for superior craftsmanship in cabinets, housings, chassis, racks, boxes, enclosures or any type of sheet metal fabrication.

WRITE FOR OUR NEW CATALOG.

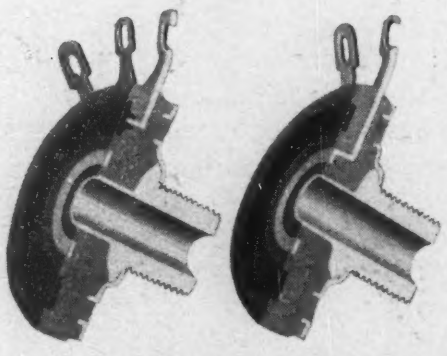
KARP METAL PRODUCTS CO., INC.

Custom Craftsmen in Sheet Metal

124 — 30th STREET, BROOKLYN 32, N. Y.



The resistor element is molded as a single unit, with insulation, terminals, face plate, and threaded bushing. There are no rivets, welded or soldered connections.



During manufacture, the resistance may be varied over its length to provide any resistance-rotation curve. After molding, heat, cold, moisture, or hard use cannot affect it.

The Bradleyometer Resistor is solid-molded and thick . . . not just sprayed film

The heart of an adjustable composition rheostat or potentiometer . . . like the Type J Bradleyometer . . . is the resistor element. If it is a fragile, sprayed film, it cannot hold up satisfactorily under frequent operation, rapid climatic changes, or overload. But if it is a thick, solid-molded ring . . . as in the Type J Bradleyometer . . . it has long, trouble-free life built into it. And its 2-watt rating has a big safety factor, too.

Type J Bradleyometers can be furnished in single, dual, or triple unit construction. Built-in switch is optional. Let us send you specifications.

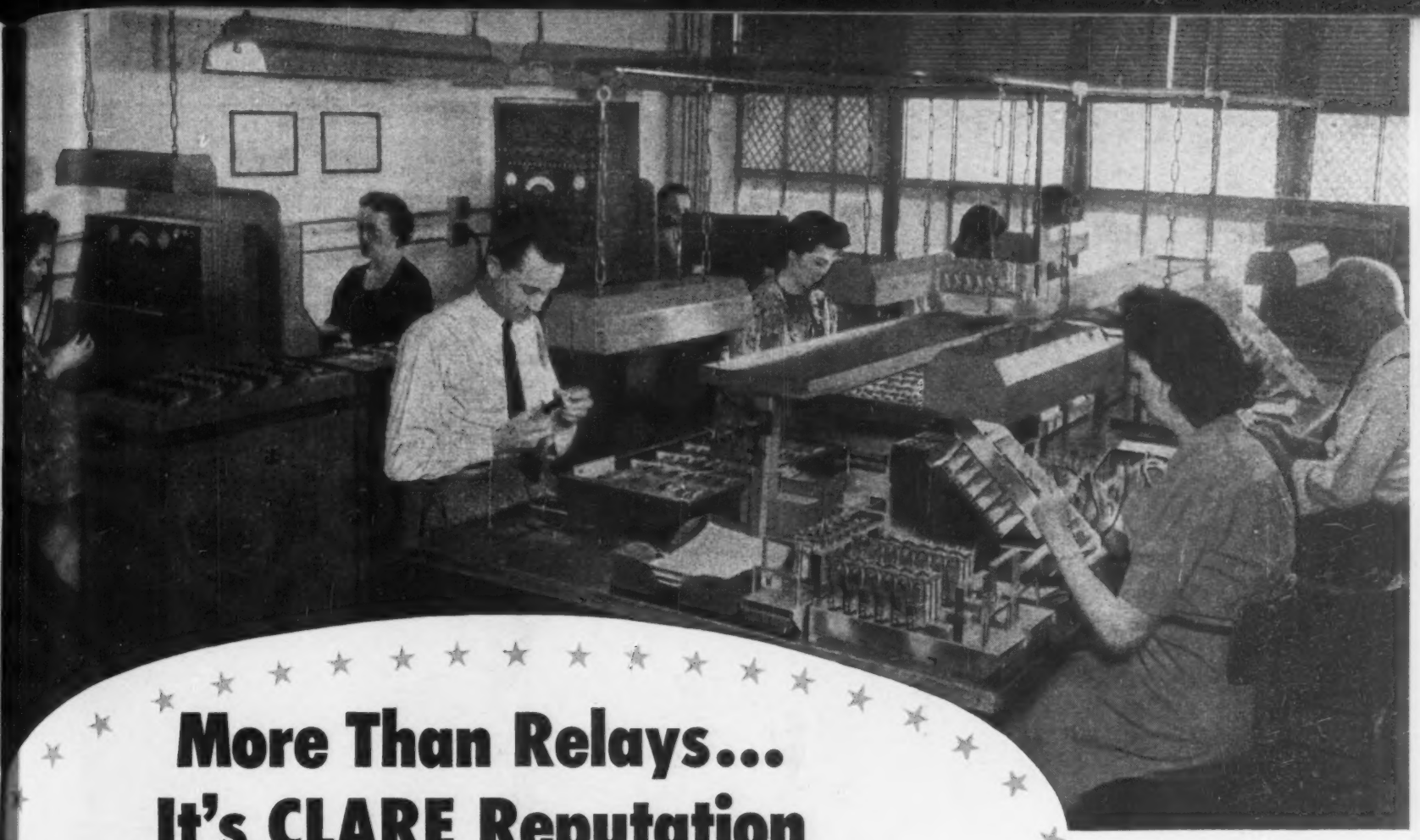
Allen-Bradley Company, 110 W. Greenfield Ave., Milwaukee 4, Wis.

A-B

ALLEN-BRADLEY

FIXED & ADJUSTABLE RADIO RESISTORS

QUALITY



More Than Relays... It's CLARE Reputation They Hold In Their Hands!

● Relays are no side line with Clare. Precise, "custom-built" relays are our stock in trade.

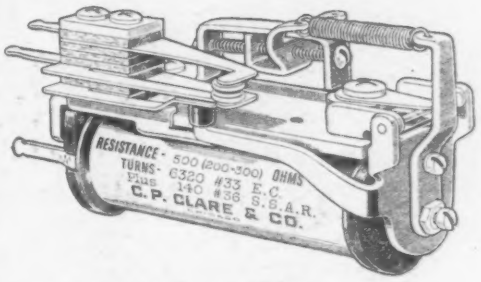
Through these trained fingers in Clare's modern test laboratory pass every Clare "Custom-Built" Relay to make sure that each fulfills the customer's requirements exactly. Operate and release current . . . contact sequence . . . contact pressure . . . coil resistance . . . high-voltage insulation . . . every detail must check.

This painstaking testing of the manufacture and precise adjustment of each relay is one reason why thousands of users of Clare "Custom-Built" Relays count on them for applications where ordinary relays won't do.

Clare "custom-building" means that the proper combination of various Clare features may be built into a standard frame so as to provide a relay ideal for the specific requirement. This makes possible a flexibility of design and construction which gives unusual operating reliability even under severe conditions of temperature, humidity, atmospheric pressure or vibration.

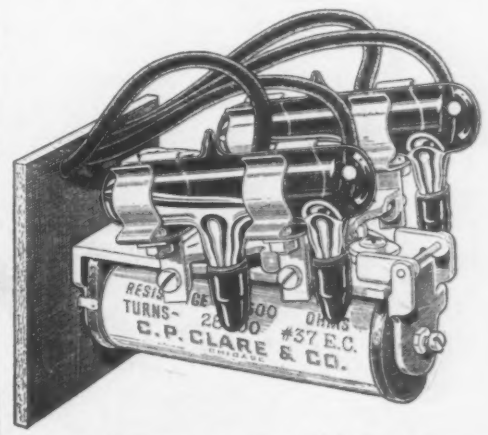
See your nearest Clare sales engineer. They are located in principal cities to work with you in the development of "custom-built" relays to meet your most unusual relay requirements. Let them show what Clare "custom-building" can mean to you. Do you have the new Clare Engineering Data Book? If not, send for your copy today. Address: C. P. Clare & Company, 4719 West Sunnyside Ave., Chicago 30, Ill. Cable Address: CLARELAY.

In Canada: Canadian Line Material Ltd., Toronto 13



Clare Micro-Adjustment Relay—This Clare Micro-Adjustment Relay is capable of unusually precise adjustments for marginal, close differential operation. It is for use in applications where extremely accurate adjustment is required.

The armature tension is adjusted by tightening or loosening the spring which is attached to a post at the armature end of the relay.



Clare Mercury Contact Relay—Shown above is a Clare Type "M2" Mercury contact relay with glass enclosed contacts. The mercury contact is mounted on a tilt table attached to the heelpiece of the relay. These relays must be mounted horizontally. Clare also provides Mercury contact relays with Bakelite enclosed contacts and with metal contacts.

CLARE RELAYS

"Custom-Built" Multiple Contact Relays for Electrical and Industrial Use

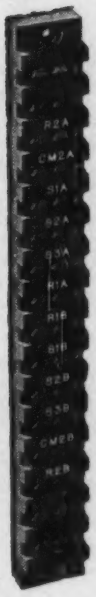
Post-formed Lamicoid laminated plastic used by RCA as an antenna case and insulating piece.

POST-FORMED LAMICOID...THE CASE FOR RCA VICTOR RADIO ANTENNAE

RCA-Victor uses a post-formed Lamicoid laminated plastic part, on which is stamped the RCA trade name, as an *insulating part*, and a case for the internal antenna on their 66BX Globetrotter—the portable radio.

Whatever *your* uses and requirements may be for a laminated plastic insulating material for electric and electronic equipment, we can supply you with Lamicoid because it is available in so many grades and types. Coil forms, panel boards, charts, signs, gears, machine parts and many other insulating or structural pieces can be made of Lamicoid to *exact* specifications.

Lamicoid has high dielectric strength,

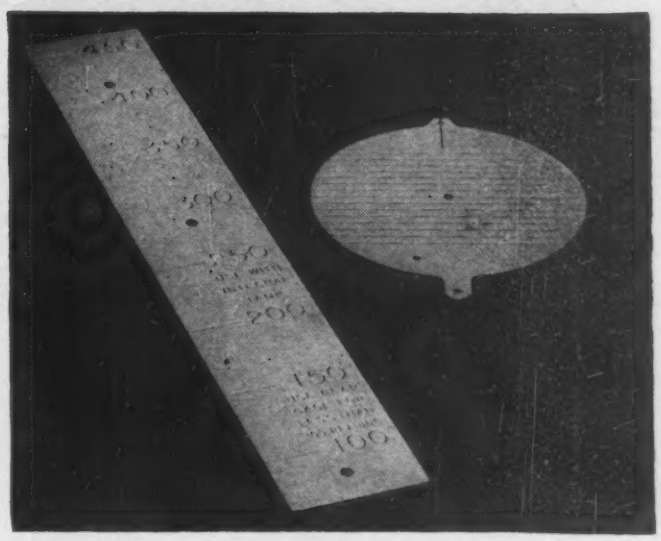


Lamicoid used on this terminal block can be machined, sawed, drilled and easily printed for circuit identification. Lamicoid sheets are obtainable with rubber for terminal connections that must be sealed against moisture and various liquids.

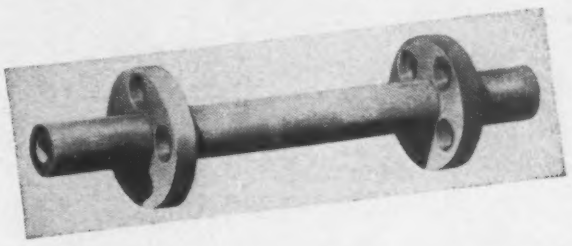
Mechanical Calculator—which utilizes graphic Lamicoid. This type of Lamicoid is widely used for wiring diagrams, instrument panels, flasher and elevator signals, etc.

high mechanical (compressive) strength, is suitable for both high and low-voltage, and low power factors—and is staple under varying atmospheric conditions. Lamicoid is available in sheets, rods and tube forms . . . and made with different resin binders to meet specific operating conditions.

Mica Insulator Company is headquarters for all types of insulating materials, backed by half a century of practical experience which dates from the very beginning of electrical insulation. That's why you can always be sure of receiving from Mica engineers honest and impartial suggestions as to the best solution to your insulating problems. Write.



Example of how graphic Lamicoid can be used as an insulating material and as an indicating medium. Available in translucent, opaque, rigid or flexible, translucent engraving or fluorescent graphic for name plates, signs, charts, diagrams.



This coil form is made of canvas-back Lamicoid. Let the Mica Insulator Company, with over 50 years of practical experience suggest the types of Lamicoid best suited to the exact requirements of *your* product.

MICA *Insulator* COMPANY

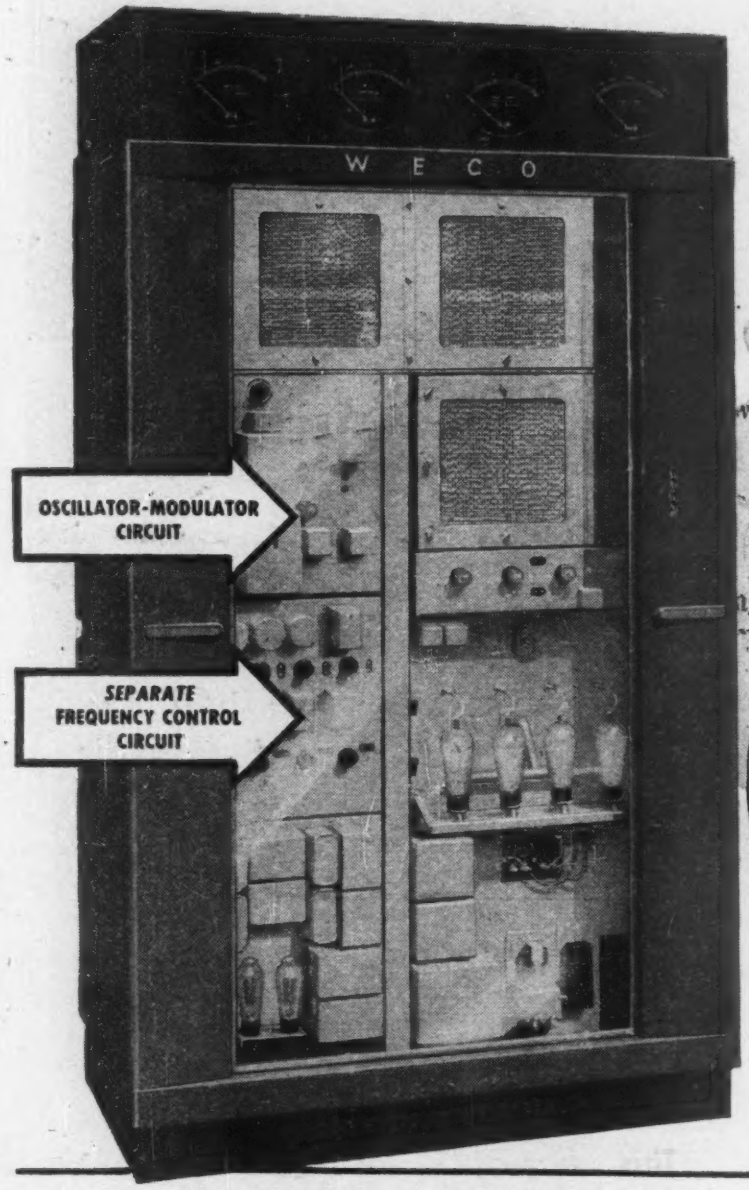
Dept. 22, Schenectady 1, New York

SALES OFFICES: Boston: 285 Columbus Avenue; Chicago: 600 West Van Buren Street; Cincinnati: 3403 Hazelwood Avenue; Cleveland: 1276 West 3rd Street; Detroit: Book Building; New York: 200 Varick Street; St. Louis: 455 Paul Brown Building; Philadelphia: 1119 Real Estate Trust Building; Rochester: 817 Commerce Building; Western Fiberglas Supply, Ltd., 739 Bryant Street, San Francisco 7; 937 South Grand Avenue, Los Angeles 15.

FABRICATORS: Lamicoid Fabricators, Inc., 3600 Potomac Avenue, Chicago, Ill.; Insulating Fabricators, Inc., 69 Grove Street, Watertown, Mass.; Insulating Fabricators, Inc., 12 East 12th Street, New York City; Bakoring, Inc., 1020 Houston Avenue, Houston 10, Texas.

Important FM news

for Broadcast Managers . . . Engineers . . . Listeners



but that it persists in transmitting and reproducing some that they do *not* play.

These tones, resulting from a process known to the engineer as cross modulation (in both transmitter and receiver) are discord-

FROM AN ARTICLE BY EDWIN H. ARMSTRONG *BROADCASTING*, JULY 1, 1946

musical ... and not like ... or-

It is FM's unique ability to transmit and reproduce only the tones actually produced in the studio that has evoked the commendation of the musical authorities heretofore referred to in this letter.

... addition to nat...ness of reproduction there is added the ... quietly ...

IT is low cross modulation (intermodulation), as Major Armstrong points out, which allows FM to reproduce only the notes actually played and thus achieve such naturalness of tone.

Western Electric's Synchronized FM transmitters are unique in FM broadcasting because of their *unusually low intermodulation products*—achieved by a complete separation of the oscillator-modulator circuit from the frequency control circuit.

For other important features of Western Electric's complete new line of FM transmitters, contact your nearest Graybar Broadcast Equipment Representative, or write to Graybar Electric Company, 420 Lexington Avenue, New York 17, N.Y.

Unexcelled Performance of Western Electric FM Transmitters

Audio Frequency Response		±0.25 DB from 30 to 15,000 cycles
Harmonic distortion — for	±75 KC swing	Less than 0.5% from 30 to 15,000 cycles
— for	±100 KC swing	Less than 0.75% from 30 to 15,000 cycles
Intermodulation — — — for	*±75 KC swing*	*Less than 0.5% for 80% 50 cycles and 20% 1000 cycles; less than 1.0% for 80% 50 cycles and 20% 7000 cycles*
FM noise level		65 DB below ±75 KC swing
AM noise level		50 DB below 100% amplitude modulation
Carrier Frequency stability		Less than 2000 cycles deviation (no crystal heater)

Western Electric

— QUALITY COUNTS —

Western Electric — Distributed by GraybaR — Offices in 68 Principal Cities

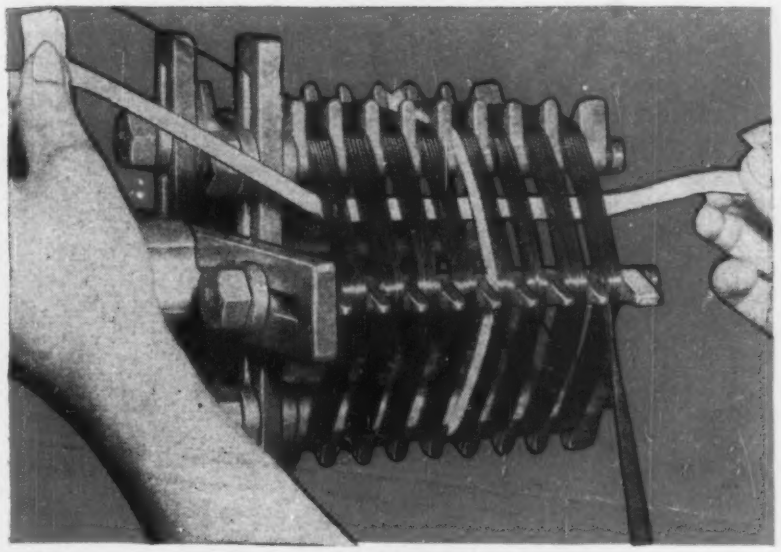
A STREAMLINED METHOD OF FASTENING MOTOR COILS *with*

REG. U. S. PAT. OFF.

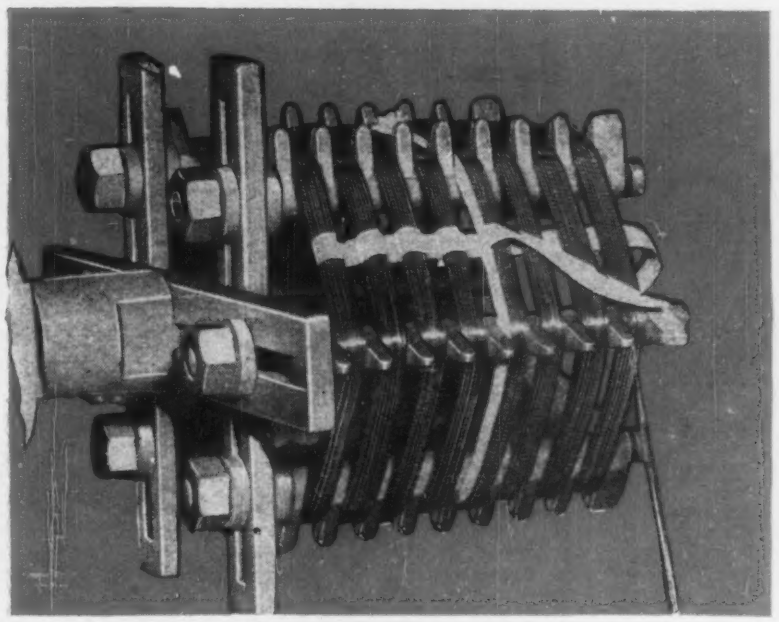
SCOTCH BRAND

Electrical

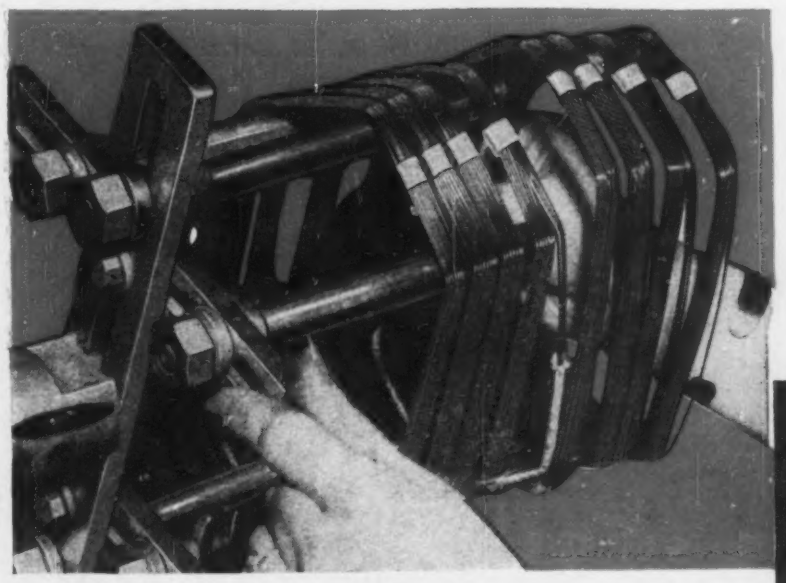
TAPE



LOOP TAPE AROUND COILS



PRESS ADHESIVE SIDES TOGETHER



CUT BETWEEN COILS

"SCOTCH" Electrical TAPE simplifies and speeds up fastening motor coils after the winding operation. The procedure is shown on the left.

1—A single piece of "SCOTCH" Electrical TAPE is passed inside the coils and brought around the outside with the adhesive side bearing against the coils.

2—The adhesive faces of the tape, pressed together between the coils, provide a tight, secure band for each coil.

3—When cut apart each banded coil is held neatly in place.

This operation is just one of the countless ways in which "SCOTCH" Electrical TAPES speed up and simplify the production of electrical equipment. There are more than twenty distinct types of "SCOTCH" Electrical TAPES, each designed to perform some specific electrical holding or insulating task. Write Department R for samples and complete information.

Made in U.S.A. By

MINNESOTA MINING & MFG. CO.

THE 3M COMPANY

SAINT PAUL 6, MINNESOTA

Accurately detects sources of wear, strain and noise . . . . .

The TELEVISO MODEL 11-B VIBROMETER

● The Televiso Model 11-B Vibrometer electronically measures the vibration characteristics of any moving surface instantly and accurately. Unnecessary wear, strain and noise no longer need be tolerated in industrial machinery, and in the integral parts of products.

The Vibrometer is an invaluable design aid. It prevents breakdowns, locates trouble, speeds production, reduces rejects.

It is particularly useful in measuring the vibration in motors, gears, bearings, rotors, fans, propellers, presses, aircraft structures, stokers, etc. Ninety-five percent of all vibration measurements needed by industry are covered.

All three types of vibration are registered on a calibrated meter scale: *displacement,* where the vibration may be felt but not seen; *velocity,* where the vibration is minute; *acceleration,* where the vibrating surface is small.

Consisting of an integrated, amplified vacuum tube voltmeter with a cable-attached piezo-electric Rochelle salt crystal search prod; the Vibrometer is equipped with interchangeable fittings which permit innumerable applications.

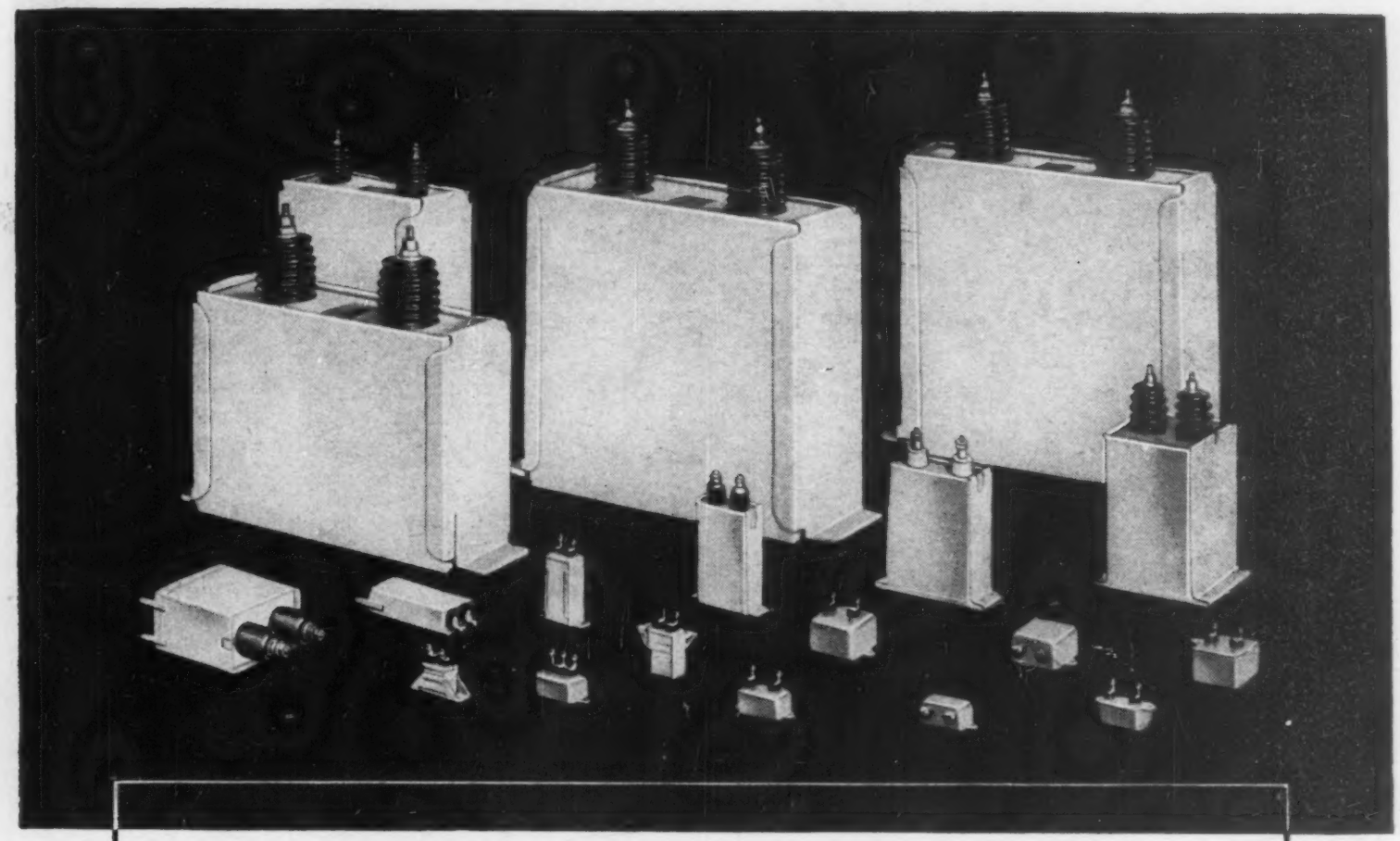
Sturdily constructed and portable, the Vibrometer is practical for field, laboratory and production use. Operation is simple. Write today for complete technical data.

Televiso
PRODUCTS CO.
7466 IRVING PARK ROAD
CHICAGO 34, ILLINOIS

Specifications

Operation:	105-125 volt, 50-60 cycle, power.
Frequency Response with Search Prod Plugged in:	5-2500 cps., uniform within 2%. Correction graph to 2 cps. can be supplied.
Weight:	31 pounds.
Size:	17" high, 12" deep, 11½" wide, 10° slope.
Displacement Range:	5 ranges, 0-.01", 0-.03", 0-.1", 0-.3", 0-1" in RMS displacement.
Velocity Range:	5 ranges (in inches per second), 0-1, 0-3, 0-10, 0-30, 0-100.
Acceleration Range:	5 ranges (in inches per second per second), 0-100, 0-300, 0-1000, 0-3000, 0-10,000.
Output Jack:	Available at rear of Vibrometer for use with phones, oscillograph, wave analyzer, or recording devices.
Construction:	All aluminum mechanical components housed in a solid oak, copper lined cabinet. The black, wrinkle-finish panel is engraved.
Guaranty:	The Vibrometer is guaranteed for two years.

HERE'S A *New Line* OF D-C CAPACITORS



BETTER IN "Civvies" FOR HAVING WON THEIR SERVICE STRIPES

It's an open secret among the trade that G-E Pyranol capacitors, which enjoyed such an enviable reputation before the war, are now better than ever!

The reason for this is obvious. Some pretty tough demands had to be satisfied during the war. The strict quality control methods, new manufacturing techniques, and improved materials, instituted at that time have produced outstanding results which General Electric has now incorporated in a new line of Pyranol capacitors designed to meet commercial requirements.

This new listing makes available a wider range of sizes, ratings, and mounting arrangements with characteristics for operation over wider temperature ranges (−55°C to +85°C), at altitudes up to 7500 ft.

These G-E *Pyranol-treated fixed paper dielectric capacitors range in size and shape from bathtub and small rectangular case styles to large, welded steel case designs. Capacity ratings from .01 muf to 100 muf, and voltage ratings from 100 to 100,000 volts are listed. The high dielectric strength and stable characteristics of the special Pyranol-impregnated Kraft paper are hermetically sealed into these non-inflammable units, thus assuring long life.

**Pyranol is General Electric's non-inflammable liquid dielectric for capacitors.*

D-C Capacitors

GENERAL ELECTRIC

407-108-5700

GENERAL ELECTRIC COMPANY
Apparatus Department, Section K 407-108
Schenectady 5, N. Y.

Gentlemen: Kindly send me further information on "Fixed Paper Dielectric Capacitors for DC Applications."

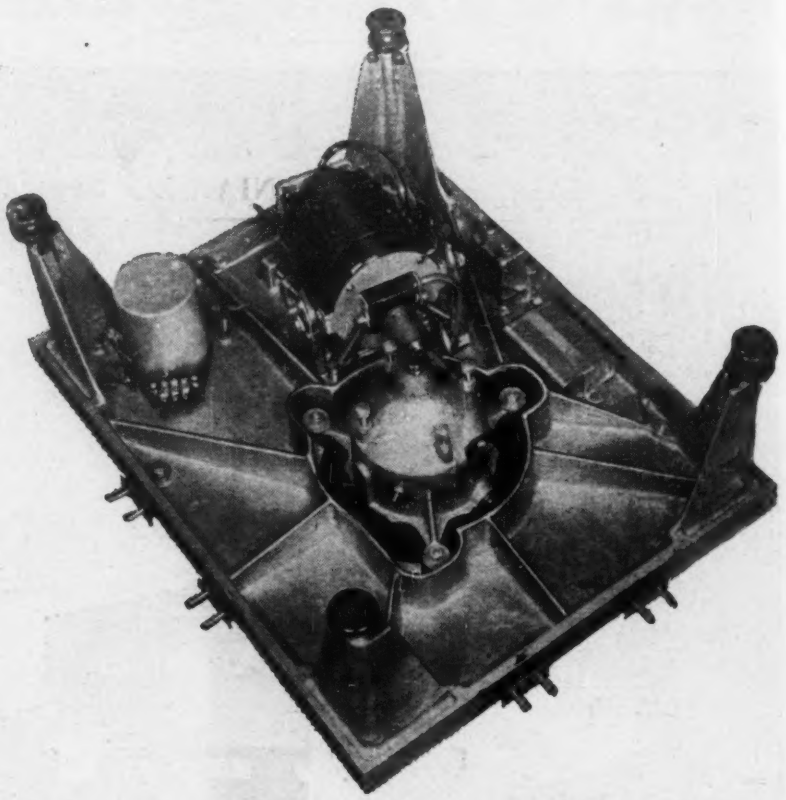
Name .....

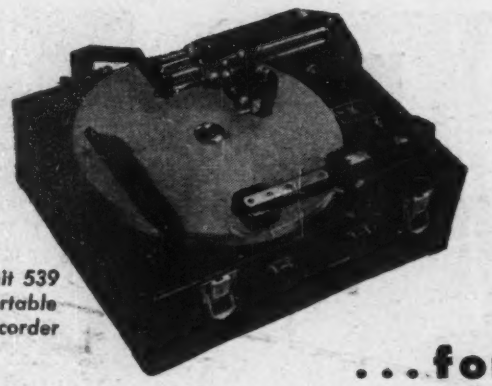
Organization .....

Address .....

City ..... State .....

Console STABILITY





Unit 539 Portable Recorder

...for professional portable recorders!

Once again, Fairchild takes the lead in improved sound equipment design—*for even finer performance.* This time it's the new cast panel and motor mount for the Unit 539 Portable Recorder, shown above.

By replacing the former lightweight panel with a sturdy, ribbed casting with integrally cast legs, Fairchild brings console stability to professional portable recorders. The full weight of the recorder mechanism is supported independently of the trunk. The entire mechanism can be removed as a unit, if desired, and leveled up on its own four legs on a bench for operations or mechanical adjustment.

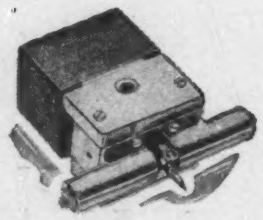
Here again, Fairchild is thinking ahead in terms of increasingly higher standards of performance for both AM and FM broadcasting and professional recording by adding vibration-free performance to already attained wide dynamic range, minimum distortion content, wide frequency range and split-second timing.

Unit 539 Portable Recorder, mounted in a trunk for portability, is designed to meet and exceed professional specifications for direct lateral recording and reproduction of sound on discs up to 16" at 33.3 rpm and 78 rpm. It is complete with cable and connectors for attachment to Fairchild Unit 540 and 295 Amplifier-Equalizers.

Where double turntable or continuous recording and direct playback are required, a second identical Unit 539 Recorder can be connected to a Unit 540 or 295 Amplifier-Equalizer.

Fairchild **CAMERA AND INSTRUMENT CORPORATION**

SOUND EQUIPMENT



UNIT 541
MAGNETIC CUTTERHEAD

FOR IMPROVED PERFORMANCE

Earlier FAIRCHILD portable models and many other types of recorder-playbacks will give vastly improved performance if equipped with an improved Fairchild Pickup and Cutterhead. For complete information address: 88-06 Van Wyck Boulevard, Jamaica 1, N. Y.

UNIT 542
LATERAL DYNAMIC PICKUP

SYLVANIA NEWS

CIRCUIT ENGINEERING EDITION

NOV. › *Prepared by* SYLVANIA ELECTRIC PRODUCTS INC., Emporium, Pa. ‹ 1946

SYLVANIA COMMERCIAL ENGINEERING DIVISION AIDS IN PRODUCING EFFICIENT SET CIRCUITS

Views of Sylvania Electric's renowned Commercial Engineering Department. Here, new discoveries from Sylvania's laboratories are built into the latest products.

Helping to engineer the best possible radio circuits for many set manufacturers is one of the numerous achievements of Sylvania's famous Commercial Engineering Department.

Time and again circuits found to be unnecessarily complicated were simplified and made even *more efficient* through the work carried on here.

For nearly twenty years Sylvania's Commercial Engineering Department has contributed to the advancement of circuit design as well as to the development of a great variety of electronic and lighting products.

SOME PRODUCTS OF SYLVANIA ENGINEERING RESEARCH

Radio receiving tubes, such as the famous Lock-In.
Miniature radio receiving tubes, including the tiny T-3.
1.4 volt battery tubes.
150 ma. line of 6.3 volt tubes.
Radio transmitting tubes.
Cathode ray tubes.
Pirani tubes.
Silicon Crystal Diodes.
1N34 and 1N35 Germanium Crystals.
Electroflash Tubes and Units.
Radio tube parts.
Fluorescent lamps.

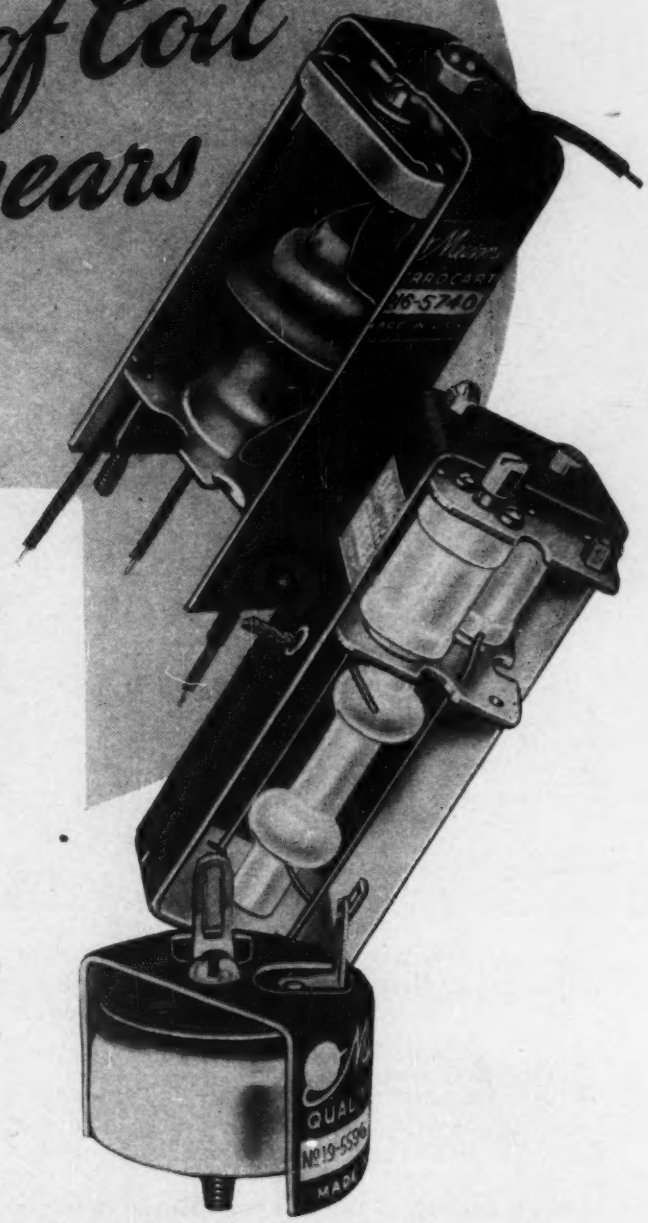
SYLVANIA ELECTRIC

Emporium, Pa.

MAKERS OF RADIO TUBES; CATHODE RAY TUBES; ELECTRONIC DEVICES; FLUORESCENT LAMPS, FIXTURES, WIRING DEVICES; ELECTRIC LIGHT BULBS

MEISSNER Coils

The Standard of Coil Quality for 24 years



Meissner Coils, long the accepted standard for engineers who insist on high quality performance, are designed to meet your most exacting requirements. Precision-made, these superior components are backed by a 24 year reputation for quality and uniformity in manufacture.

A complete line, including Air Core Plastic I. Fs, Iron Core Plastic I. Fs and standard I. Fs. Send for free catalog.

Available Soon!

The new Hazeltine Combination AM-IF and FM-IF Single Unit Coils. The answer to space and production problems in the design of AM-FM receivers.

WRITE FOR FULL INFORMATION

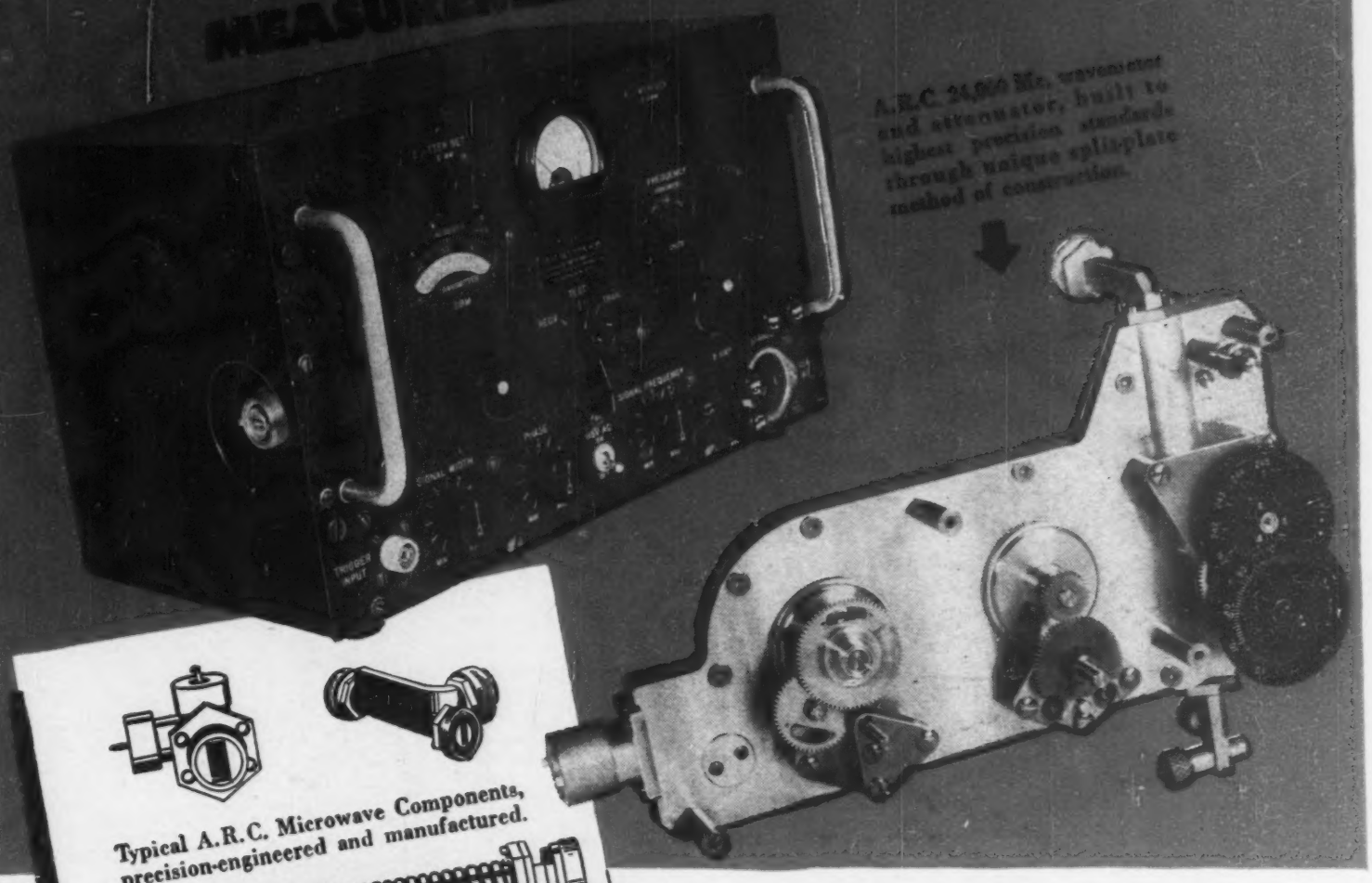
ELECTRONIC DISTRIBUTOR AND INDUSTRIAL SALES DEPARTMENT

MAGUIRE INDUSTRIES, INC.

936 N. MICHIGAN AVENUE · CHICAGO 11, ILLINOIS

Now Available!

MICROWAVE TEST AND MEASUREMENT EQUIPMENT BY ARC



A.R.C. 24,000 Mc. wavemeter and attenuator, built to highest precision standards through unique split-plate method of construction.

Typical A.R.C. Microwave Components, precision-engineered and manufactured.

Recently released from Army-Navy classification, this equipment, formerly known as the TS-223/AP, is now being produced by Aircraft Radio Corporation as the A.R.C. Test Set, Type H-10.

This highly specialized test equipment is used primarily for the measurement of radar receiver sensitivity, frequency and band width; and transmitter power and frequency, in the 24,000 Mc. band. Other field or laboratory measurements possible with this equipment include testing of type 2K50 r-f oscillator tubes and measurement of radar receiver recovery time.

The heart of the A.R.C. Test Set, the 24,000 Mc. wavemeter and attenuator, is available separately, if desired.

For full information on A.R.C. microwave accessories and component parts, write

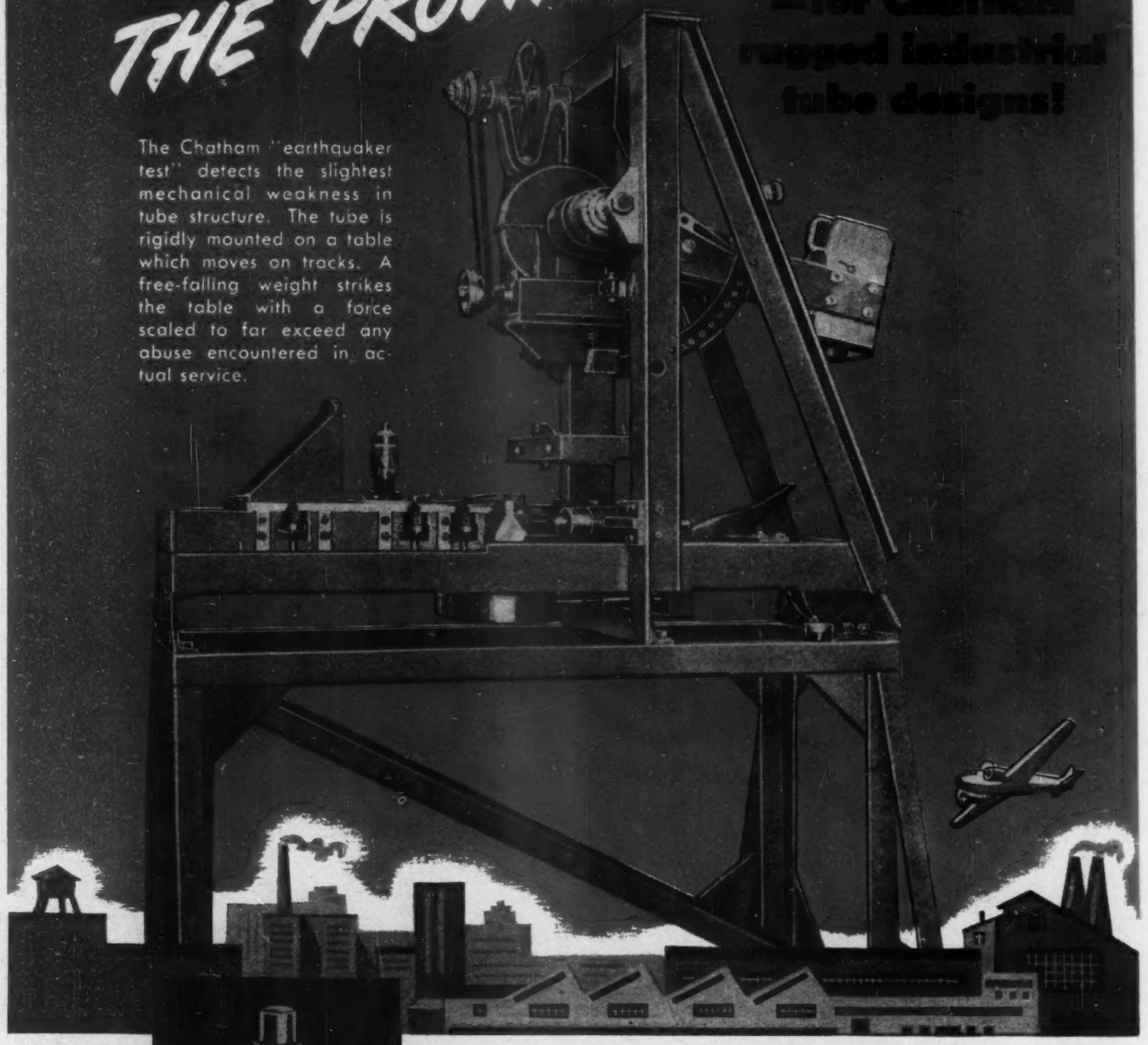
NOW AVAILABLE: **free, illustrated catalog of A.R.C. Radio and Electronic Component Parts and Accessories**

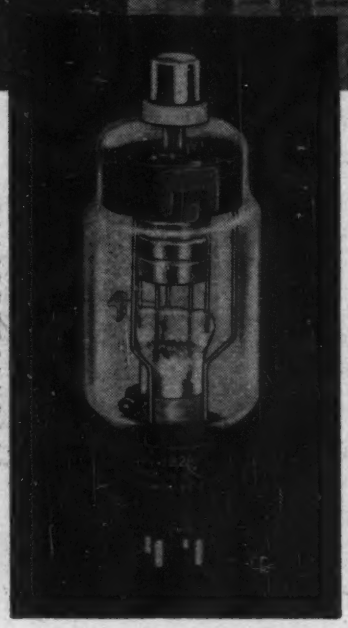
AIRCRAFT RADIO CORPORATION

BOONTON, NEW JERSEY

This high impact shock machine is THE PROVING GROUND —for Chatham rugged industrial tube designs!

The Chatham "earthquaker test" detects the slightest mechanical weakness in tube structure. The tube is rigidly mounted on a table which moves on tracks. A free-falling weight strikes the table with a force scaled to far exceed any abuse encountered in actual service.





INERT GAS RECTIFIERS

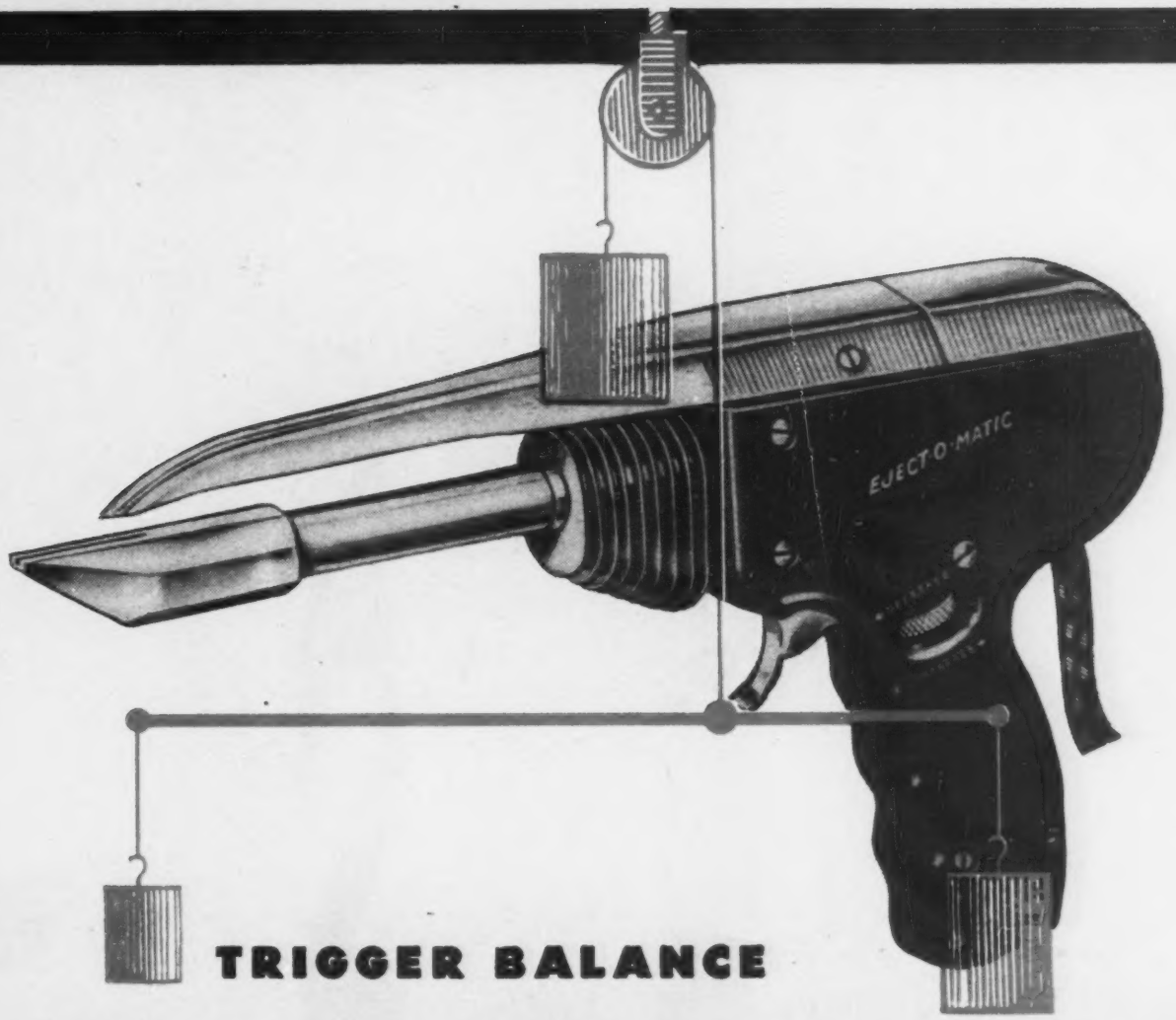
CHATHAM Xenon rectifier and thyratrons perform perfectly under wide extremes of ambient temperature without blowers, thermostats or other auxiliaries to maintain bulb temperature. They are recommended for industrial, airborne and other installations where reliability is a prime consideration.

Chatham engineering and design research far surpasses ordinary methods and procedure in pre-detecting and analyzing electronic rectifier tube characteristics under severe operating conditions. Vibration, shock and other mechanical abuse—the usual "death knell" for tubes in heavy industrial applications—are dealt with in the blueprint stage of manufacture.

For example, CHATHAM is one of the few manufacturers equipped to subject their tubes to this positive test of stamina. For this reason, we suggest that users of rectifiers, thyratrons and special types check their needs with CHATHAM engineers—particularly where severe operating conditions are involved. Simply call or write on company letterhead. There is no obligation for this CHATHAM service.

CHATHAM ELECTRONICS

475 WASHINGTON STREET, NEWARK 2, NEW JERSEY



Reduces fatigue factor—speeds production

Light weight, and non-tiring balance are built-in features of the Eject-O-Matic. This modern soldering tool weighs only 20 ounces fully loaded with a 4-ounce reel of solder. The center of gravity is located near the trigger. The molded, pistol-grip handle fits the hand snugly, and the fatigue factor is reduced to minimum. Eject-O-Matic can be used for hours without tiring the operator! And actual industrial tests prove that it speeds up production — nearly doubles the output per operator.

Eject-O-Matic is available in 50, 75 and 100 watt models — 150 and 175 watt models in production soon.

WEIGH THESE ADVANTAGES

Automatic Feed

Micrometer Control of amount of solder ejected

Automatic Retracting Feature

Cooling Fins dissipate excess heat

Drop-forged, Non-corrosive Tip
Safety, Utility Base

Model 19-S *(illustrated)* with base—retails at $18.95

Individually packed. Shipping wt. per carton of 12 units, approx. 42 lbs.
Send for *literature*

AUTOMATIC-FEED SOLDERING TOOL
EJECT-O-MATIC
HOUSES · MEASURES · EJECTS THE SOLDER

MULTI-PRODUCTS TOOL COMPANY, 123 SUSSEX AVENUE, NEWARK 4, NEW JERSEY

FROM ANY ANGLE..

POWERSTAT TYPE 20

(VARIABLE TRANSFORMER)

IS SUPERIOR

In the market for a small variable transformer of about ½ KVA capacity? To be more specific . . . INPUT — 115 volts, 50/60 cycles, 1 phase. OUTPUT — 0-135 volts or 0-115 volts, 3.0 amperes.

Take a look at POWERSTAT type 20.

Viewed from any angle it qualifies as a superior voltage controller.

QUALITY ANGLE . . . The mechanical construction is extremely rugged yet this POWERSTAT is unusually compact for the rating.

Mounting holes are located on a 1¼ inch radius.

Excellent regulation, smooth control, high efficiency are only a few of its desirable electrical features.

VERSATILITY ANGLE . . . Type 20 can be connected to provide increasing voltage with either clockwise or counter-clockwise rotation. Terminals permit clip-lead or solder connections.

COST ANGLE . . . Highest valuation yet lowest price per rated ampere output of any similar type variable transformer.

Other angles regarding type 20 will be cheerfully discussed by SECO sales-engineers. . . *Consult us NOW!*

Send for Bulletin 150 LE

THE SUPERIOR (SECO) ELECTRIC COMPANY

711 LAUREL STREET — BRISTOL, CONNECTICUT, U. S. A.

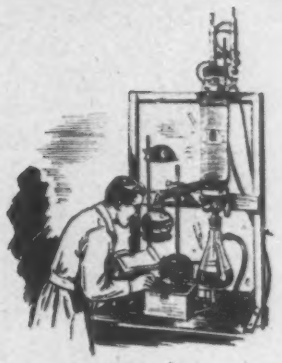
*RICHARDSON MEANS *Versatility* IN PLASTICS

Don't Look Now—But Here it Comes!

What's the mystery . . . here *what* comes? Chances are, it's a problem in plastics. We get them every day. It may involve an insulating part for an electrical application, or a non-corrosive part for chemistry. It might turn out to be a quieter streetcar bearing, collector rings on a power shovel, or thread advancing reels for textile applications. Whatever it is . . . Richardson *versatility* will soon have it solved.

For here you deal with practical people in an old, established firm whose sole business is plastics; where diversified equipment and adequate research, design and engineering personnel have been established to provide you with the complete plastics service you like . . . but seldom find.

INSUROK *Precision Plastics*

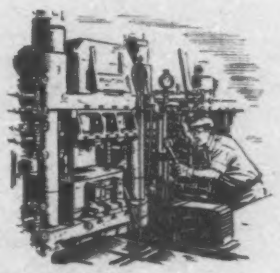


***RESEARCH**
. . . a continuous transformation of possibilities into practical ideas in plastics.

***DESIGNING**
. . . Artistic visualization. Creative engineering. Practical planning for efficient plastics production.

***PRODUCTION**
. . . Complete machine shop facilities for manufacturing dies, molds and tools.

***LAMINATING**
. . . Sheets, rods, tubes. Standard NEMA grades; over 700 special grades.



***MOLDING**
. . . Rubber and bituminous plastics; and synthetic resin plastics . . . Beetle, Bakelite, Durez, etc.

The RICHARDSON COMPANY

Sales Headquarters: MELROSE PARK, ILL. FOUNDED 1858 LOCKLAND, CINCINNATI 15, OHIO

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INDIANAPOLIS, IND.

Factories: MELROSE PARK, ILL. • NEW BRUNSWICK, N. J.

For Truly Fine Sound Recording

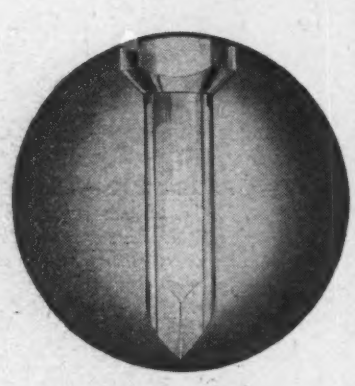
Professional Recordists Recommend . . .

Sapphire Recording audiopoints

Designed for the professional - Guaranteed to do a professional job

With These *Three* Outstanding Features

- INDIVIDUALLY DISC-TESTED ON A RECORDING MACHINE.
- EXPERTLY DESIGNED TO INSURE PROPER THREAD THROW.
- A PRODUCT OF THE MANUFACTURER OF AUDIODISCS — AMERICA'S LEADING PROFESSIONAL RECORDING BLANKS.



The jewelled point, with 87° included angle, correct radius and fine polish, cuts a silent shiny groove for many hours. When dulled or chipped, these points may be resharpened several times. Each resharpened Audiopoint is disc-tested to insure perfect performance. For this service return points through your dealer.

Professional recording engineers know, from years of experience, that Sapphire Recording Audiopoints offer the ultimate in recording styli. Made by skilled craftsmen to most exacting specifications and individually tested in our laboratories, these Audiopoints are of consistent fine quality.

A good recording stylus requires a perfectly matched playback point. The Sapphire Audiopoint for playback fills this need completely. In materials, workmanship and design, it is the finest playback point obtainable. (Should not be used on shellac pressings.)

These Audiopoints are protectively packaged in handy cellophane covered cards—cards that are ideally suited for returning points to be resharpened.

OTHER POPULAR AUDIOPOINTS, that complete a full line of recording and playback styli, are: Stellite Recording Audiopoint, a favorite with many professional and non-professional recordists; Diamond-Lapped Steel Audiopoint, a recording stylus particularly adapted for non-professional recordists; Playback Steel Audiopoints (Straight Shank and Bent Shank), the most practical playback points for general use. One hundred per cent shadowgraphed.

For further information, see your Audiodiscs and Audiopoints distributor, or write

AUDIO DEVICES, INC.
444 Madison Ave.,
New York 22, N. Y.

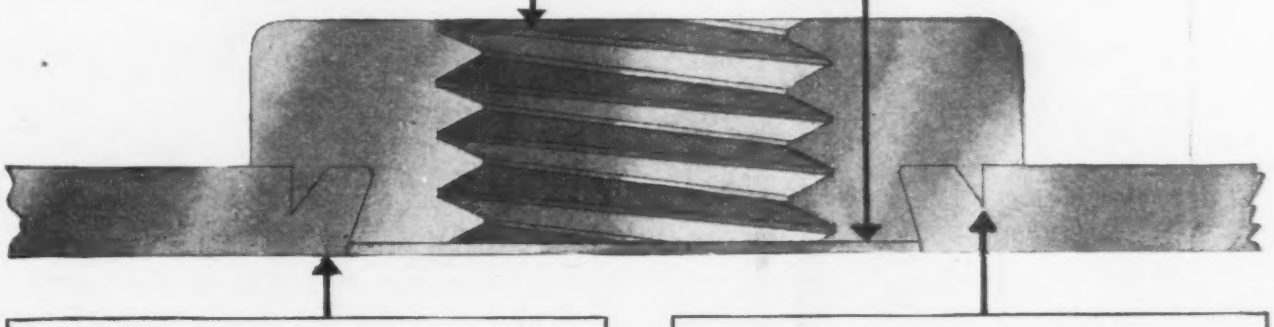
NEW!

Self-Clinching Fastener

PROVIDES LOAD-CARRYING THREADS IN THIN STEEL, ALUMINUM, COPPER OR BRASS SHEET!

1 *Provides load-carrying threads in thin steel, aluminum, copper, or brass sheet!*

2 *Shank length can be equal or less than thickness of sheet!*

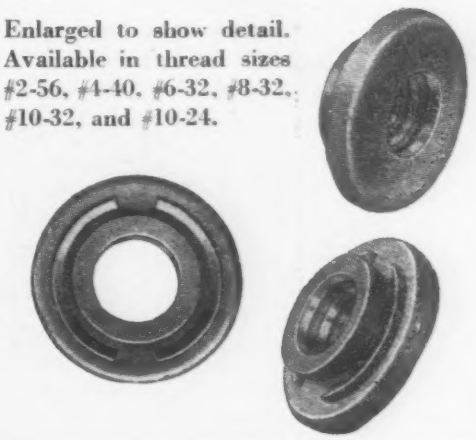


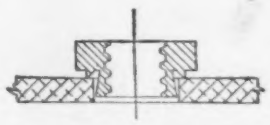
3 *Countersinking of hole not necessary. Reverse side of sheet remains flush!*

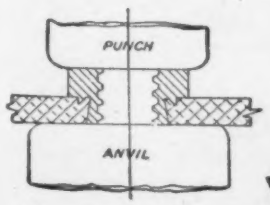
4 *Ring clinches fastener and prevents turning.*

PEM Self-Clinching Fasteners solve assembly problems involving steel, aluminum, copper, or brass sheet. Because no special tools are required, PEM Self-Clinching Fasteners save time, labor, and weight; mean faster, more simplified clinching. Use the coupon to get complete information.

Enlarged to show detail. Available in thread sizes #2-56, #4-40, #6-32, #8-32, #10-32, and #10-24.







IT'S THIS EASY! Punch straight hole, insert fastener in sheet, and apply pressure to head of fastener.

PEM

PENN ENGINEERING & MANUFACTURING CORP.
SOUTH MAIN STREET, DOYLESTOWN, PA.

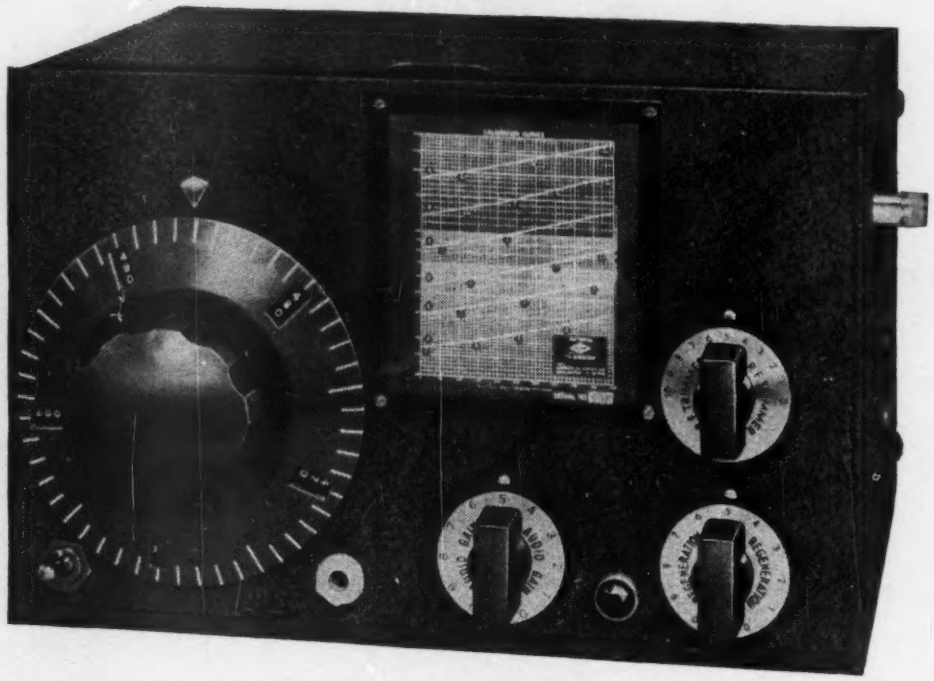
PENN ENGINEERING & MANUFACTURING CORP.
SOUTH MAIN STREET, DOYLESTOWN, PA.

Please send me complete information about the new PEM Self-Clinching Fastener.

NAME.....

COMPANY.....

ADDRESS.....



THE 1-10A

The ONE-TEN-A is a complete redesign of the ONE-TEN, retaining all the proven design features of the older model but with improved performance and smoothness of control.

For many years the ONE-TEN has been the "standard" receiver for work in the range from one to ten meters. Although many advances in high frequency technique have been made since this little receiver was first introduced, it has easily held its place in the affections of experienced amateurs by its consistent dependability under actual operating conditions and its high usable sensitivity.

The new ONE-TEN-A inherits the fine qualities of its predecessor brought up to date by a complete restudy of circuit, mechanical arrangement and constructional details.

The ONE-TEN-A is a fine receiver.

NATIONAL COMPANY, INC. MALDEN, MASS.

RUGGED*

Light-weight—Resilient
NATIONAL
VULCANIZED FIBRE
protects against shock and strain
...in products or plant equipment

If it's a *rugged* material you want to protect your products or plant equipment against shock and strain —you're sure of getting it in tough, durable National Vulcanized Fibre!

One of the strongest materials per unit weight known, this versatile, hard vulcanized fibre can "take it" in every way. Resilient and light in weight (about half that of aluminum), it has outstanding impact, tensile and dielectric strength . . . is extremely resistant to wear and abrasion . . . and is machined and formed easily, economically. You get all this and toughness, too, in National Vulcanized Fibre.

To be sure of improved performance for your products or plant equipment, let a trained National engineer show you how this rugged material can be readily adapted to your production. Write for information.

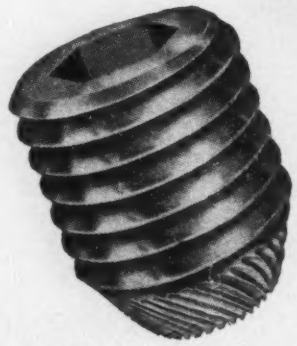
*Trunks must be built to "take" the hard knocks to which they're subjected. That's why so many of them —including U. S. Army foot lockers —are made of *rugged* National Vulcanized Trunk Fibre.

NATIONAL VULCANIZED FIBRE COMPANY

Wilmington 99, Delaware *Offices in Principal Cities*

SEE OUR CATALOG IN SWEET'S

But we have little things too



Pat'd. & Pats. Pend.

"Unbrako" Self-Locking Set Screws DO come in #0 size—with all the quality, accuracy and strength of the big #1" size.

"Unbrako" Socket Set Screws with the knurled Cup-Point are *Self-Lockers*—because the *knurled point digs in and holds firm* . . . regardless of the most chattering vibration. The tiny size of these screws—with their almost microscopic knurling has made them invaluable to manufacturers in Electronics, Electrical and Radio Industries.

Made with the accuracy and skill for which "Unbrako" products are famous, these "Unbrako" Socket Set Screws with knurled cup-point are outstanding for accuracy, hardness and strength.

"Unbrako" and "Hallowell" products sold entirely through distributors.

You can't screw socket screws in or out without a socket hex wrench,—so why not get our #25 or #50 "Hallowell" Key Kit which contains most all hex bits.

UNBRAKO

Reg. U. S. Pat. Off.

Knurling of Socket Screws originated with "Unbrako" in 1934.

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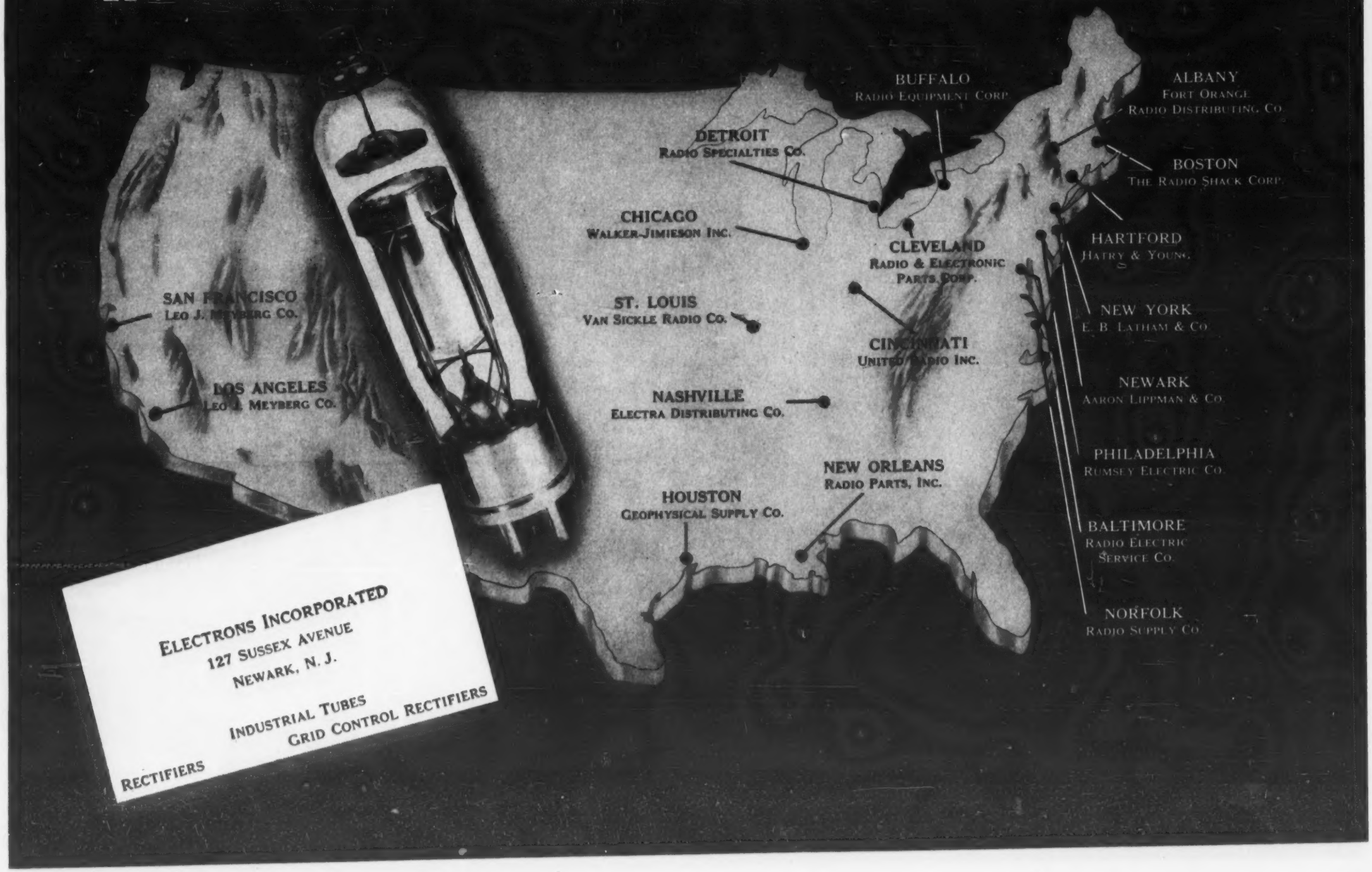

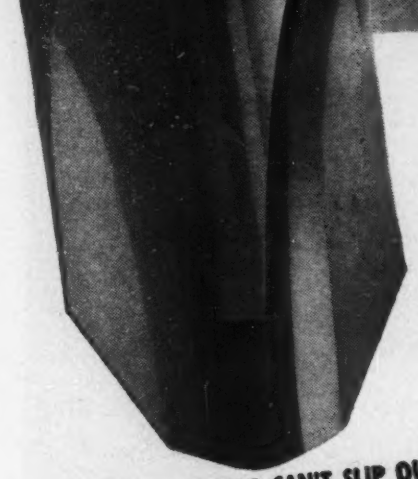

4-WINGED DRIVER CAN'T SLIP OUT OF PHILLIPS TAPERED RECESS

AMERICAN PHILLIPS SCREWS are "FIRST MATES" Cost-wise

...BOTH TO BOAT-BUILDERS AND OWNERS

In shipyards (as in automobile plants, refrigerator factories — *or what's yours?*) American Phillips Screws deliver these special savings: Swift, sure-handed handling. Automatically straight driving. Protected, unspoiled work-surfaces. More and better work done far more easily. All of which translate into TOTAL TIME-SAVINGS AS HIGH AS 50%!

And American Phillips savings reach straight through to the buyer of the boat. For these screws resist corrosion, withstand vibration, remove screw-driving from his maintenance work, help to keep his craft always trim, tight, and shipshape.

You can steer by this: American Phillips Screws are profitable not only production-wise. They're potent sales promotion, as a mark of quality construction . . . and they're sound sales-protection, too. *You* can get these same production and sales advantages in American Phillips Screws in any type or metal (see below) for any fastening requirement. Write.

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POWR-PAKT MOTORS

Alliance Powr-Pakt Motors will open and close valves, switches, operate toys and motion displays, actuate parts in business and vending machines, and can be used as component power sources in electronic control systems.

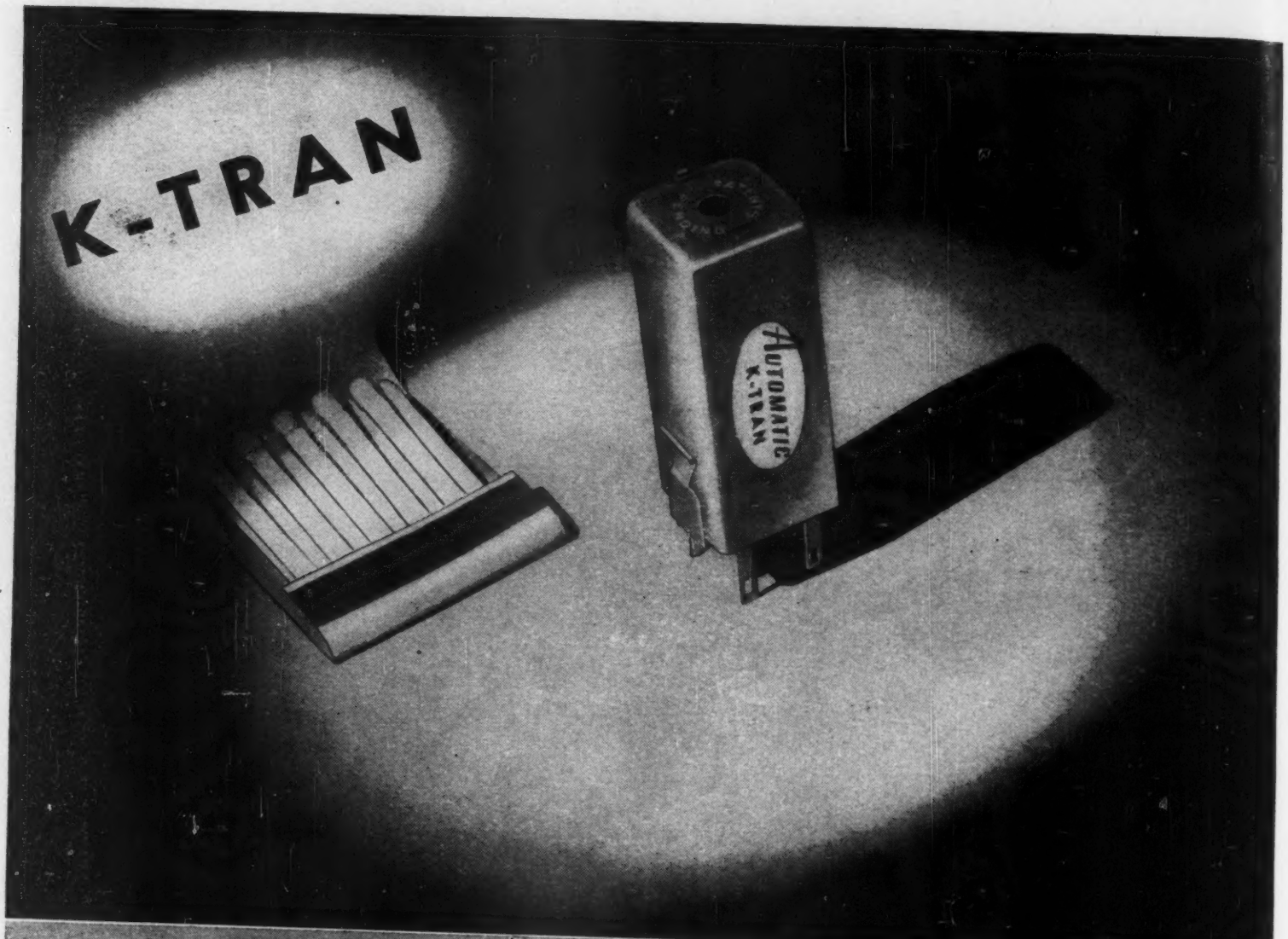
The Model 80 Phonomotor has been the outstanding favorite of manufacturers and jobbers who want a power source that's smooth, quiet, and time-tested. This is the No. 1 motor for driving turntables and record changers!

For original equipment and replacement, the leading radio manufacturers and jobbers of radio parts *rely* on Alliance Phonomotors and Powr-Pakt Motors to drive their turntables, record changers, recording and tuning devices.

Alliance Motors are mass produced, precision built, and low in cost. Besides Phonomotors, Alliance makes a wide range of small motors designed to meet the special demands of small loads. Write!

WHEN YOU DESIGN—KEEP alliance MOTORS IN MIND

ALLIANCE MANUFACTURING COMPANY • ALLIANCE, OHIO



MODERN!

THE K-TRAN is very small.

THE K-TRAN equals the performance of old style I.F. Transformers many times its size.

THE K-TRAN is standard. At 455 KC or 265 KC, four types meet practically every need, eliminating the need for many different numbers.

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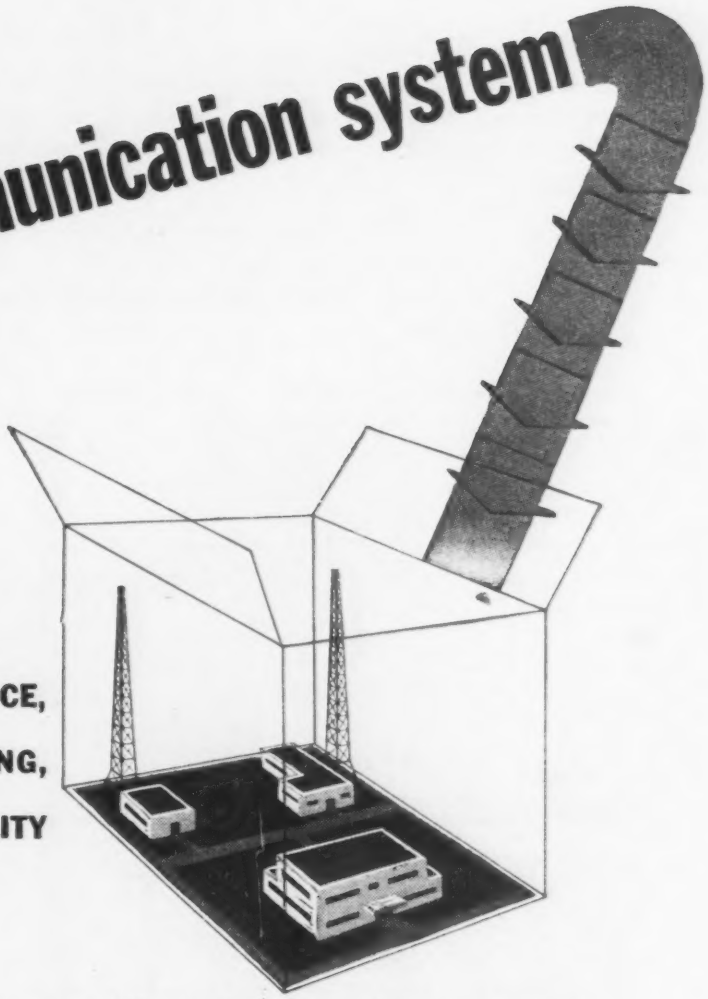
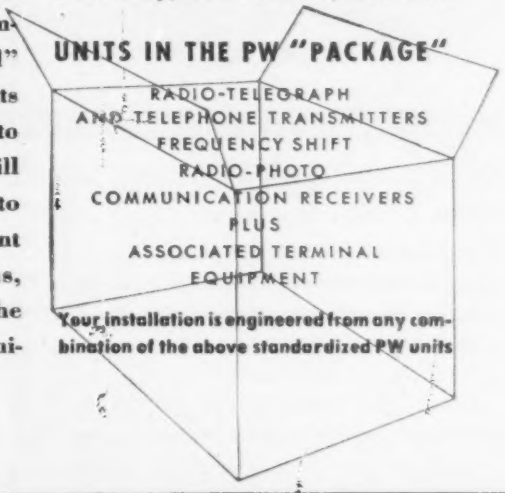


. . . FROM ONE WORLD-RENOWNED SOURCE, YOU CAN OBTAIN ANALYSIS, ENGINEERING, MANUFACTURING AND INSTALLATION ABILITY

BUILDING A COMPLETE communication system to meet your particular needs is a job for experts. Unless all units in the system are properly integrated, the end result may prove unsatisfactory and costly.

In spite of the fact no two communication problems are identical, Press Wireless—with their world-wide operating and manufacturing experience—can engineer a combination of standardized units to do your job. Obviously, such a procedure results in greater efficiency, lower cost.

After thorough analysis, and this means much more than "desk work", PW will present recommendations for your "packaged" communication system—all units of which are designed and built to work together. Such a system will be complete from soil analysis to antenna tower, even to equipment housing where necessary. Thus, you will be able to obtain all the factors of a successful communication system from *one source*, under *one contract*. Press Wireless Mfg. Corp., Executive Offices, 1475 Broadway, New York 18, N.Y. USA



PRESS WIRELESS INC.

PRESS WIRELESS

First in "Packaged" Communications Equipment

At 225 miles...13,000 feet **VHF reception** **good** *reports American Overseas Airlines...*

VHF TEST FLIGHT

Engineering Report

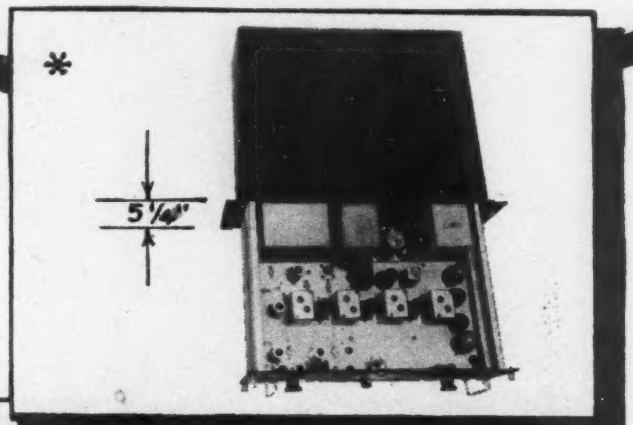
Crew: Capt. Robert Ditsworth
Comm. Engr. Reprs. J. E. Mac Dowell
H. S. Keen

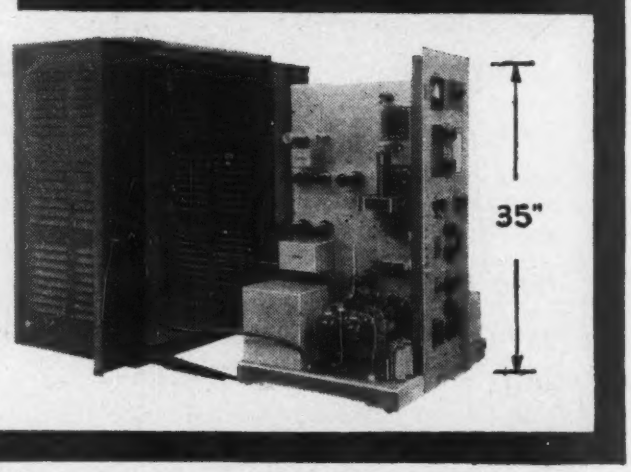
Aircraft NC 90421
Date 8/20/46

Time Off: 11:30 EST (AM)
Return : 4:30 EST (PM)

The purpose of this report is to transmit the results of a test flight made by members of the communications engineering department to gather data for an analysis of the range and quality of the VHF installation at LaGuardia.

*Transmitter: Radio Receptor TV-50A Output Power - 50 watts
*Receiver : Radio Receptor RV-1A
Antenna : Ground Plane - located atop Marine Terminal, LaGuardia Field
Frequency : 123.6 Meg.





EXHAUSTIVE VHF tests made from an American Overseas Airlines "Flagship" show conclusively the consistent results produced by Radio Receptor VHF installation at LaGuardia Field—over considerable distances as well as on short-range low-level work. Here are the highlights of test results:

"NO FAILURE OR STATIC . . ." On a descent from 13,000 feet to CFR through heavy cumulus overcast—at a distance over 150 miles—accurate ground checks were possible at all times. "NO FAILURE OR STATIC WAS ENCOUNTERED."

". . . GOOD COMMUNICATION WAS MAINTAINED" At a 5,000-foot altitude a full 360° check on a ten-mile radius produced good communication with no low spots in reception. West of the station a descent was made to 1,000 feet. At this altitude New York City buildings obstructed a line-of-sight signal ". . . BUT GOOD COMMUNICATION WAS MAINTAINED."

"HIGHLY SATISFACTORY" Readable communication with LaGuardia Field was maintained over a route covering Long Island and lower New England to a distance of 225 miles. At this distance the Flagship at 13,000 feet received transmissions from the Radio Receptor installation with an R5-S5 signal. From these results American Overseas Airways concludes—"THE INSTALLATION IS HIGHLY SATISFACTORY FOR ITS PURPOSES."

Radio Receptor VHF equipment and navigational aids for all airport and airline ground installations have records of dependability throughout the world. For complete results of the test above or for more information about Radio Receptor equipment, write today.

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Please send me the bulletins checked: Dept. C-9

- ☐ "Packaged Radio Station RSV-1" (VHF)
- ☐ "Packaged Radio Station RSL-1" (low frequency)
- ☐ LF Transmitter (Bulletin No. 5009)
- ☐ HF Receiver (Bulletin No. 5008)
- ☐ VHF Receiver (Bulletin No. 5007A)
- ☐ VHF Transmitter (Bulletin No. 5006)
- ☐ "Highways of the Air" (the story of airway radio)

Name_____

Position_____

Company_____

Address_____

City_____ State_____

Communications Division

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Since 1922 in Radio and Electronics

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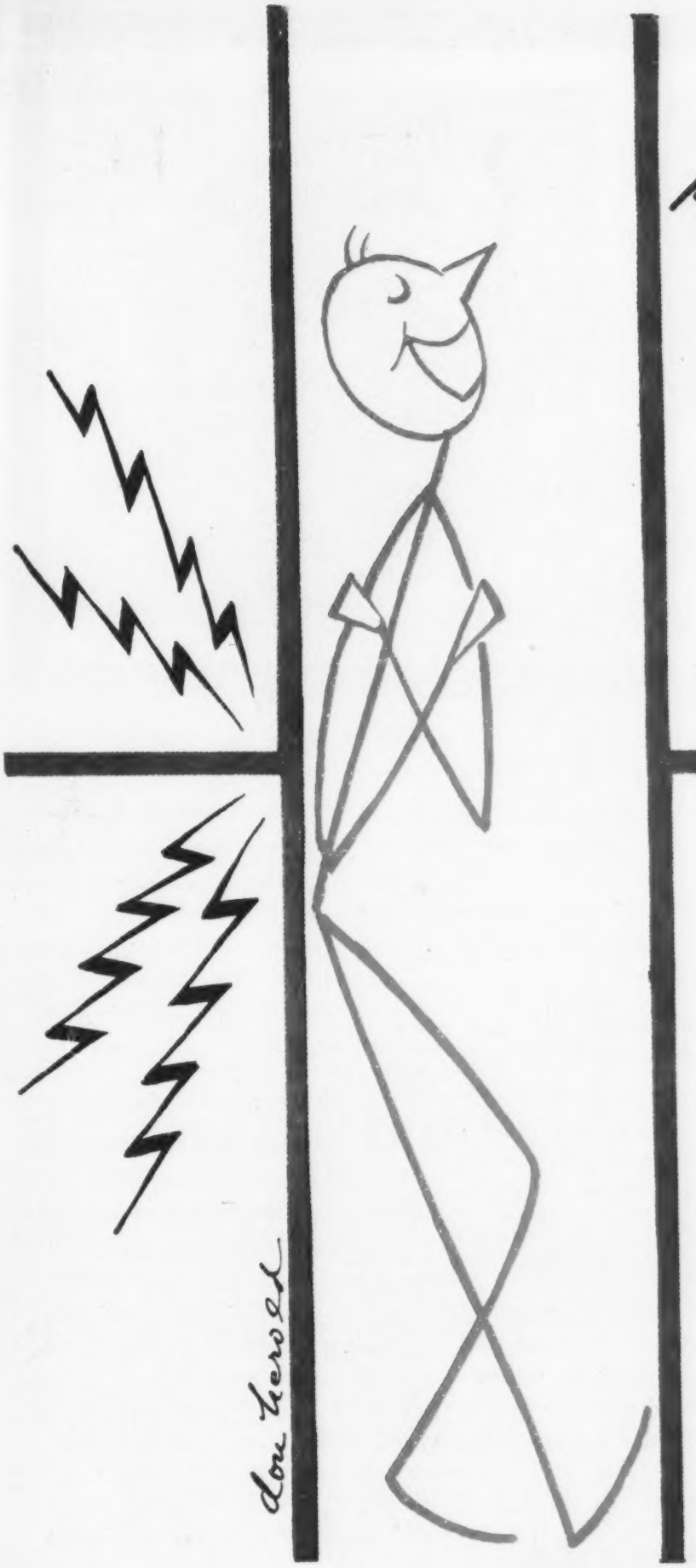
Export Representatives: RCA International Division, New York



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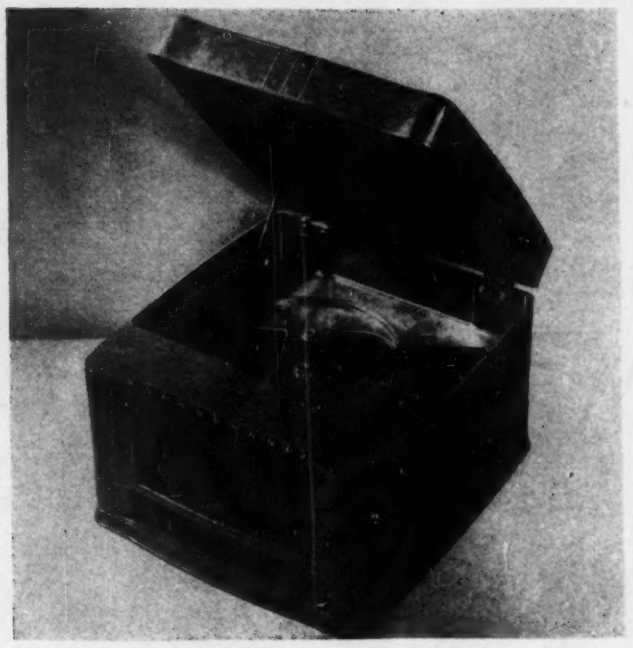


INTERESTED IN LARGE PLASTIC PIECES?

Dispelling the time-worn theory that large molded plastic pieces are impractical and uneconomical, these Admiral phonograph and radio-phonograph cabinets effectively demonstrate that large products as well as small can be molded of Durez phenolic plastics.

The bigger cabinet (right) when assembled contains a five-tube radio and automatic record player. The molded Durez body weighs 9½ pounds and the cover 3½ pounds. This makes a total cabinet weight of only 13 pounds.

Radio Frequency Preheat

Compression-molded in a 400-ton press, the special Durez compound used in this larger unit is preheated by radio frequency. This modern method of production facilitates the molding operation considerably and results in the strong, attractive cabinet shown.

The smaller unit, Admiral's automatic record player, is also molded of Durez but in a 300-ton press.

Why Plastics?

The progressive Admiral Corporation experimented and found that for top quality cabinets of this type—having light weight and an integral, lustrous finish, plastics were better suited than any other material.

Why Phenolic Plastics?

The excellent moldability, impact strength, eye-appealing finish, and the non-resonance of phenolic plastics proved the decisive factors in the choice of these most-versatile-of-all-plastics.

Why Durez Phenolic Plastics?

As specialists in the production of phenolic plastics for the past quarter century, the Durez staff have developed more than 300 multi-propertied Durez phenolic molding compounds from which to select the plastic that precisely fits the job.

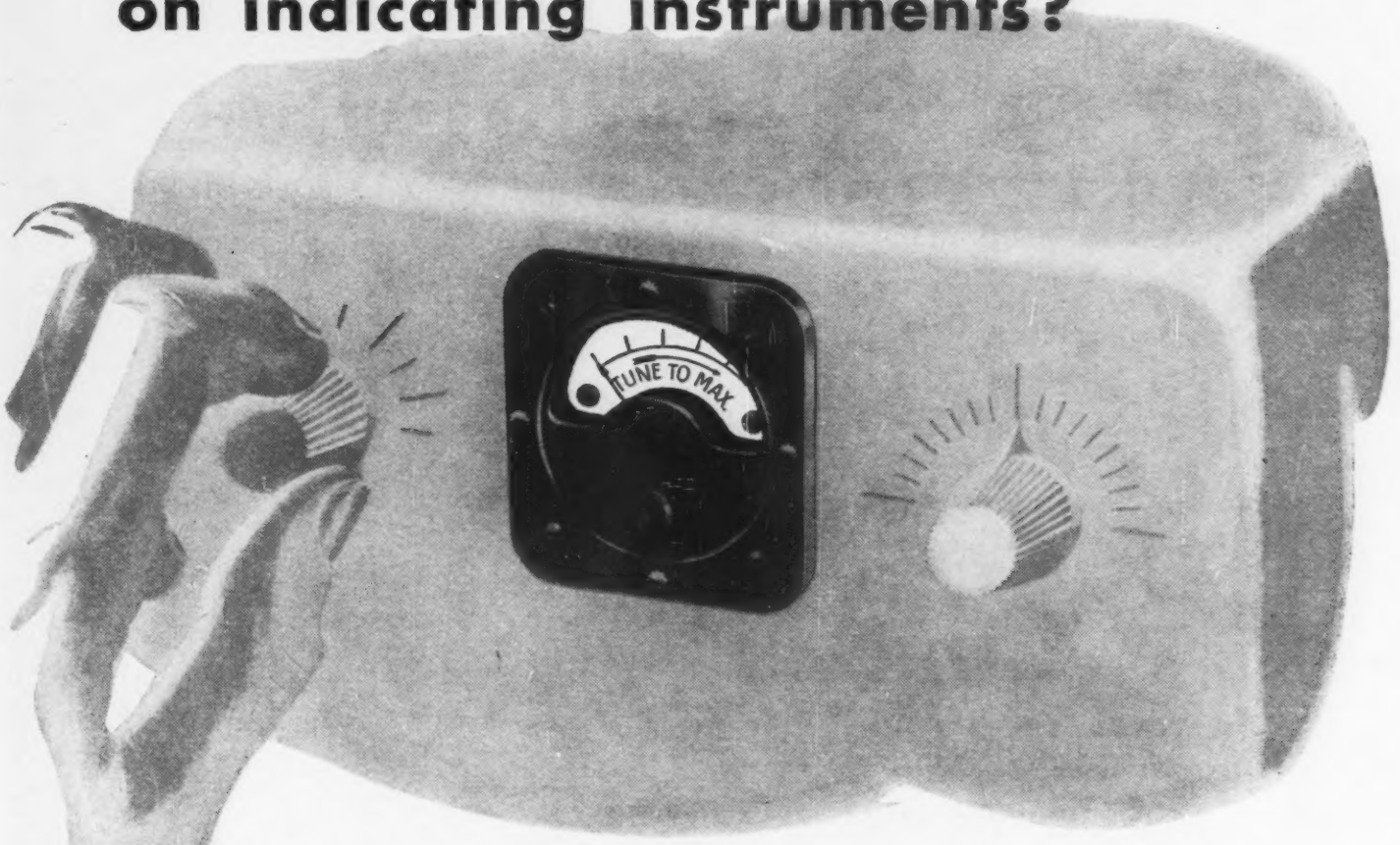
Write for Free Booklet

"Machining Data on Phenolic Plastics" is an informative manual which covers all the standard machining operations encountered in the average plant. Write for your free copy. No obligation, of course. Durez Plastics & Chemicals Inc., 811 Walck Road, North Tonawanda, New York. *Export Agents: Omni Products Corporation 40 East 34th Street, New York 16, N. Y.*

PLASTICS THAT FIT THE JOB

WHAT'S YOUR VIEW POINT

on indicating instruments?



FOR CLOSE-UP READING . . .

LOOK AT THIS MB PRECISION MINIATURE

ANY INSTRUMENT WORTH INSTALLING should be easy to read . . . but from its *working distance.* There's no need to specify bulky instruments with long-range readability when readings are made at arm's length.

In MB miniatures, you get the *smallest, lightest instruments of this type made!* You save not only on space and weight, but on cost. At a reasonable price, you assure an indicating job done with practical precision. For though miniature in size, MB instruments have large-meter accuracy (within ±2% at every point). They have a high torque-to-coil-weight ratio . . . a good measure of sensitive, speedy response and long life. In fact, because they've *standard size* sapphire bearings and steel pivots supporting just a "wisp" of coil weight, MB instruments wear indefinitely!

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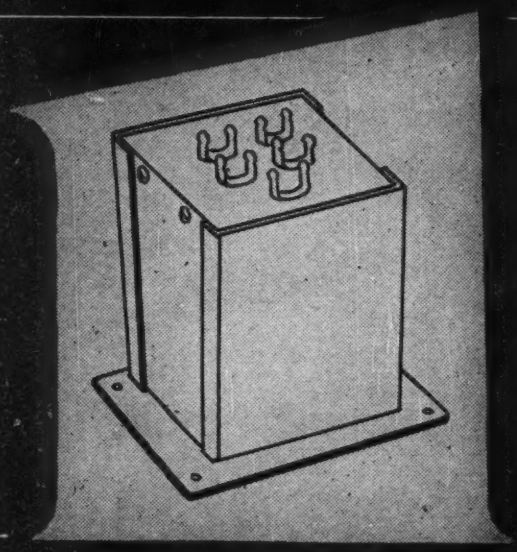

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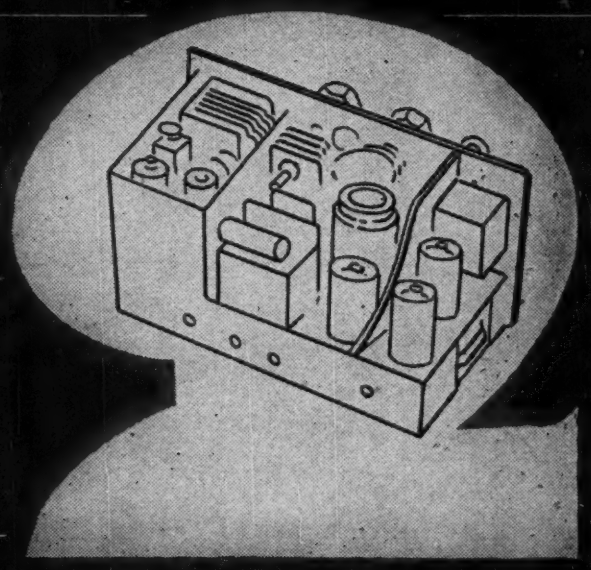

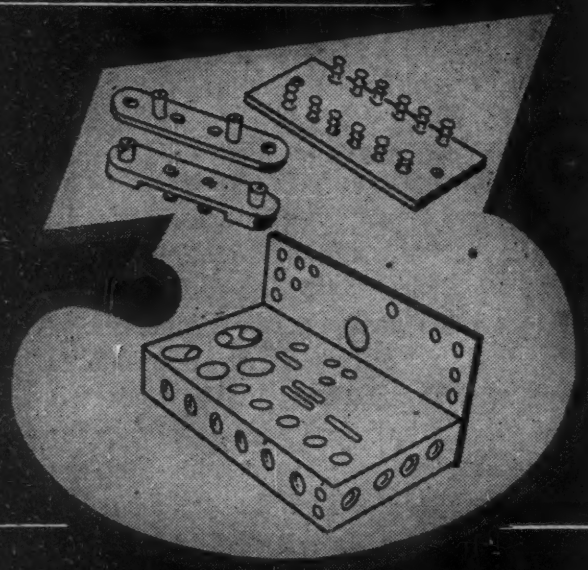

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FROM SHEETS, RODS AND TUBES — PANELS
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CUT — PUNCHED — DRILLED — ENGRAVED
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QUALITY — AT LOW COST . . PROMPT DELIVERY

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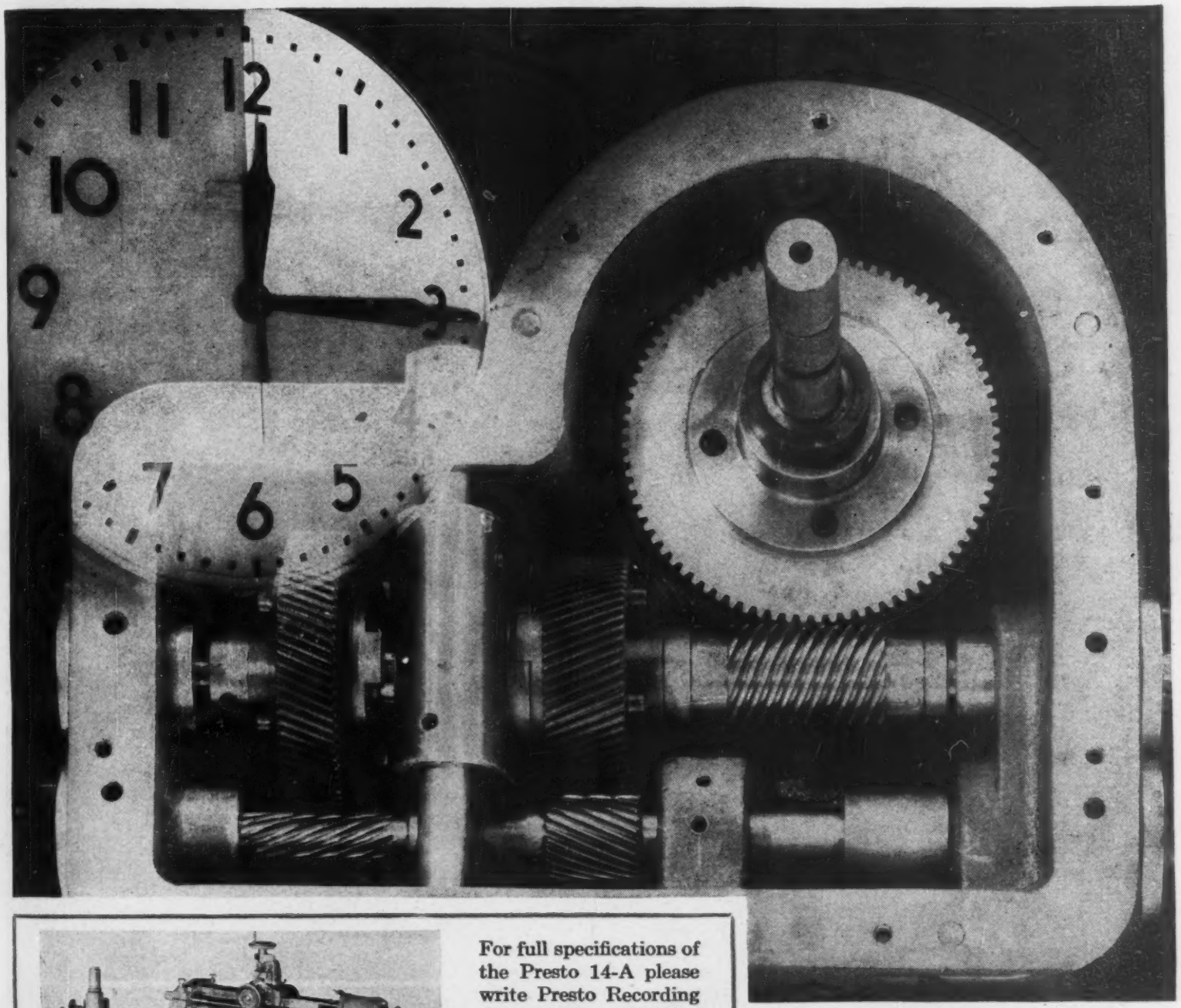
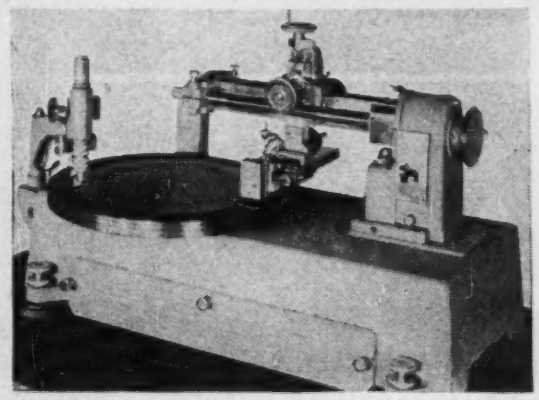
SEND US YOUR SPECIFICATIONS FOR IMMEDIATE ATTENTION

Playback Time = 15 Minutes ± Zero

▶ Directly gear-driven at both 78.26 and 33.33 rpm by a synchronous motor, the playing time of recordings made on the Presto 14-A corresponds to the original program time with split-second accuracy. The only deviation in speed may be due to variations in power supply frequency which seldom exceed 0.1%. Rotational flutter and background noise from mechanical sources are at an absolute minimum.

▶ The Presto 14-A represents a major advancement in the design of recording turntables, having all of the performance characteristics demanded by experienced engineers. Illustrated below is the new 14-A gear drive.





For full specifications of the Presto 14-A please write Presto Recording Corporation, 242 West 55th Street, New York 19, N.Y. To insure future delivery within a reasonable time, we suggest you place your order on our priority list since orders are considerably in advance of production.

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try this for Size!

where Space is a limiting factor

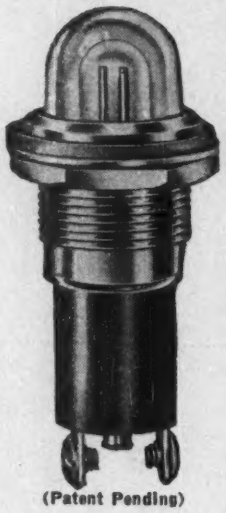
CONSIDER GENERAL ELECTRIC SELENIUM RECTIFIERS

Important savings in space and weight are realized when you design General Electric Selenium Rectifiers into electronic equipment. They'll give you more direct current per cubic inch, more per pound, than alternate types. General Electric offers a wide selection of capacities and sizes, from the mighty midget pictured above which delivers 4 volts at 0.1 milliampere to single stacks rated at 110 volts, 4 amperes.

Whatever your requirements, General Electric Selenium Rectifiers pack a lot of punch where space is at a premium. They withstand extreme variations in ambient temperature, humidity, and atmospheric pressure. You can depend upon them for long, faithful service in series, parallel, or series-parallel arrangement.

For a booklet of facts and figures, write direct to Section A-18-12119, Appliance and Merchandise Department, General Electric Company, Bridgeport 2, Connecticut.

GENERAL ELECTRIC



(Patent Pending)

"DIALCO" PLN-849 *Pilot Lights*

Designed for the New Neon-51 Lamp

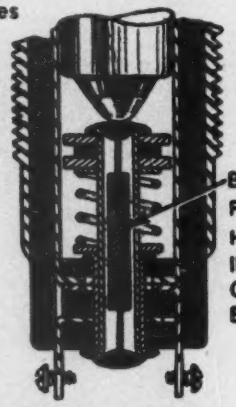
Feature BUILT-IN RESISTORS

For 110 Volts (and higher)

A RUGGED UNIT. Consumes a small amount of current (under one milliampere) and has dependable long life.

Note these important features of PLN-849 Pilot Light:

(1) RESISTOR INTEGRAL with socket assembly. Value to suit supply voltage.
(2) Moulded Bakelite Socket.
(3) Full-view Jewel Plastic Cap for visibility at all angles.
(4) Rugged terminals, binding screw or permanent soldering type.
(5) High resistance to vibration or shock.
(6) Supplied complete with General Electric Neon NE-51 Bulbs. May also be adapted to accommodate General Electric Radio Panel Bulbs such as 47, 44, etc., for low voltage circuits. Bulbs removable from front of panel.



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See your jobber—and try Rubyfluid Flux today. Paste and Liquid for general use and liquid for Stainless Steel.

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BEFORE 1941 the Henry P. Segel Company, and the manufacturers of radio-electronic components it represents, had attained a distinguished reputation for experience—service—dependability . . .

DURING the war years, this team of nationally known producers and efficient representatives "delivered the goods" to hundreds of satisfied customers . . .

NOW, in peacetime, the Henry P. Segel organization and the manufacturers it represents can supply *you* with the radio and electronic components you need— coils, condensers, controls, meters, relays, resistors, speakers and other production essentials—delivered as promised.

We invite your inquiries.

Henry P. Segel Co.

Manufacturers' Representatives Field Engineers
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Tels.: KENmore 3012-6333-9755
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Bagshaw's NEEDLES

FAMOUS SINCE 1892
for Better Record Performance

Maybe the very first "cutting" was done with the grand-daddy of this famous recording needle . . . for BAGSHAW came in with the talking machine itself! Preferred in sound studios where only the BEST will do . . . perfect cutting mate for our great transcription Needle that you know so well!

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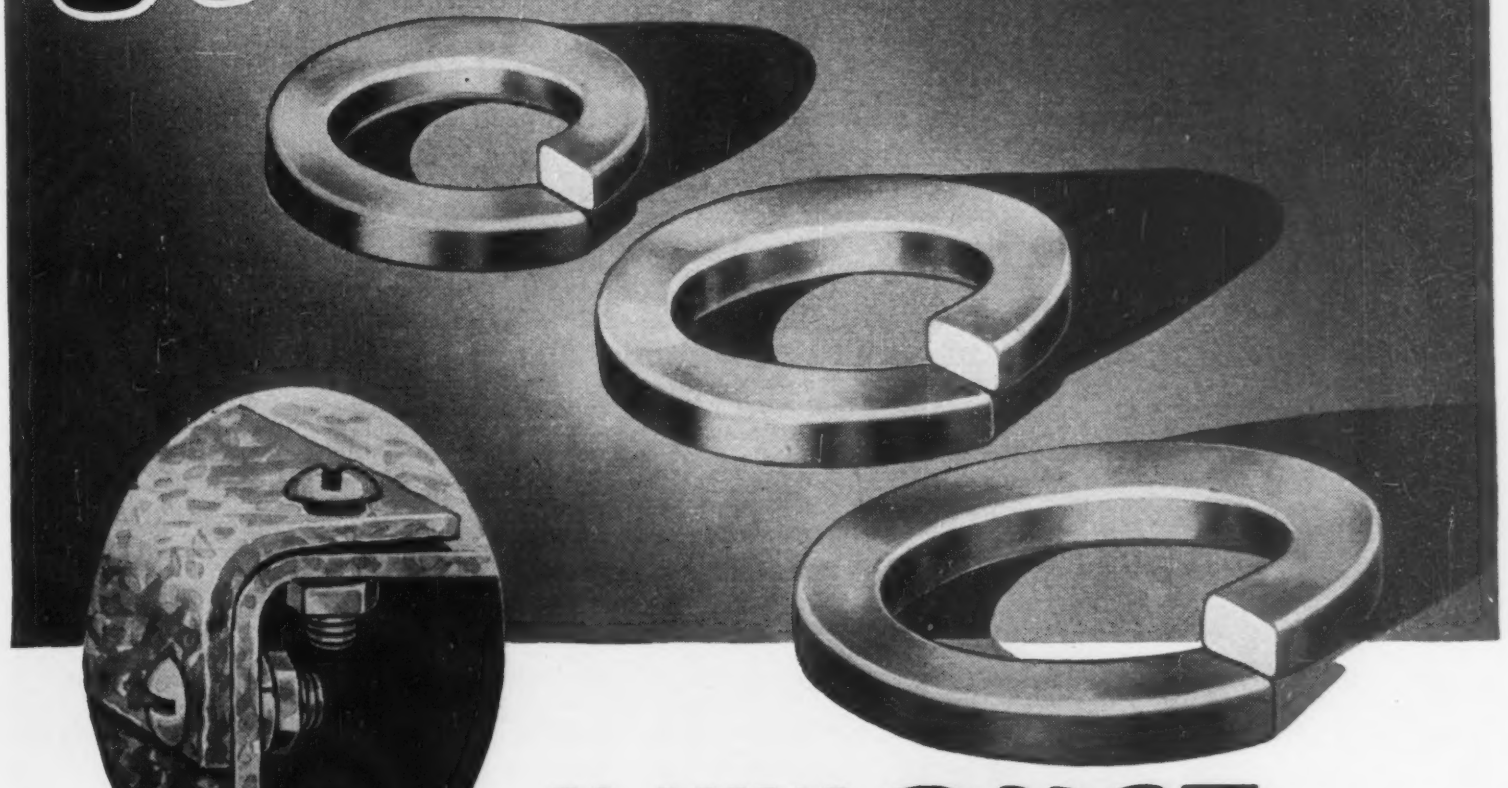
USE SPRING LOCK WASHERS



TO DEFEAT RUST AND CORROSION

Rust . . . corrosion . . . deterioration of metal parts often means loose assemblies and breakdowns unless the bolt or screw is equipped with a spring lock washer.

***A spring lock washer,* like a Diamond G Lock Washer, will keep a constant tension between the bolt, the metal parts and the nut. Any loosening that may take place because of rust or corrosion is immediately taken up by Diamond G Controlled Tension.**

***Remember* there is only one *Diamond G Controlled Tension Lock Washer.* This exclusive tension quality is built into every Diamond G Lock Washer by precision fabrication and heat treating. It permits full tightening of bolt and screws, safeguarding against excessive vibration, shock and wear.**

***Next time* specify Diamond G's! For samples and full details on the new ASA and SAE specifications on spring lock washers just write to . . .**

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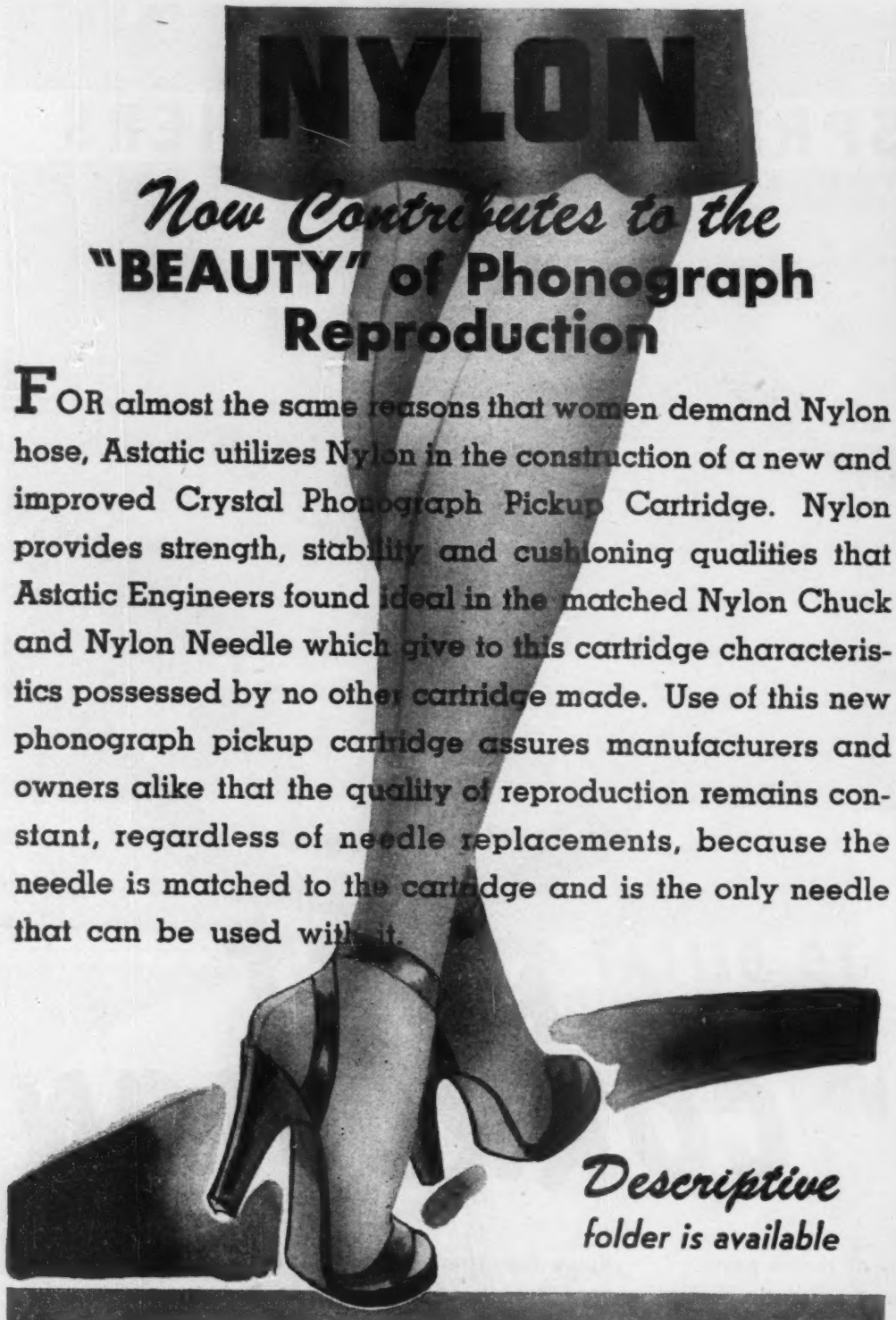
FOR almost the same reasons that women demand Nylon hose, Astatic utilizes Nylon in the construction of a new and improved Crystal Phonograph Pickup Cartridge. Nylon provides strength, stability and cushioning qualities that Astatic Engineers found ideal in the matched Nylon Chuck and Nylon Needle which give to this cartridge characteristics possessed by no other cartridge made. Use of this new phonograph pickup cartridge assures manufacturers and owners alike that the quality of reproduction remains constant, regardless of needle replacements, because the needle is matched to the cartridge and is the only needle that can be used with it.

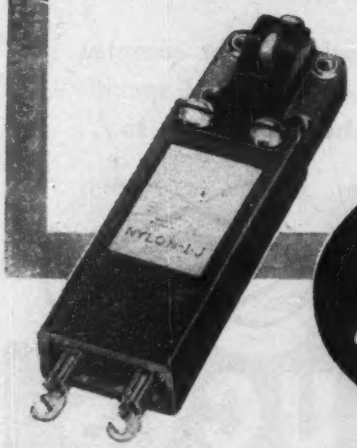


Descriptive folder is available

NYLON 1-J Crystal Pickup Cartridge

This cartridge employs a Nylon Chuck and matched, sapphire-tipped, knee-action, REPLACEABLE Nylon Needle.

Improves tracking and signal transmission. Reduces needle talk, needle scratch and resonance peaks. Increases record and needle life.



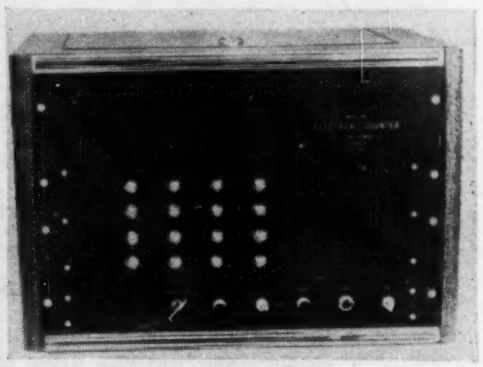
THE *Astatic* CORPORATION
ASTATIC
CONNEAUT OHIO
IN CANADA: CANADIAN ASTATIC LTD. TORONTO ONTARIO

Astatic Crystal Devices Manufactured under Brush Development Co. patents.

ideal for color photography. A circuit employing a 120-microfarad capacitor charged to 2,500 volts is used to flash the tube for about 200 microseconds. It can be flashed four times a minute.

Decimal Scaler

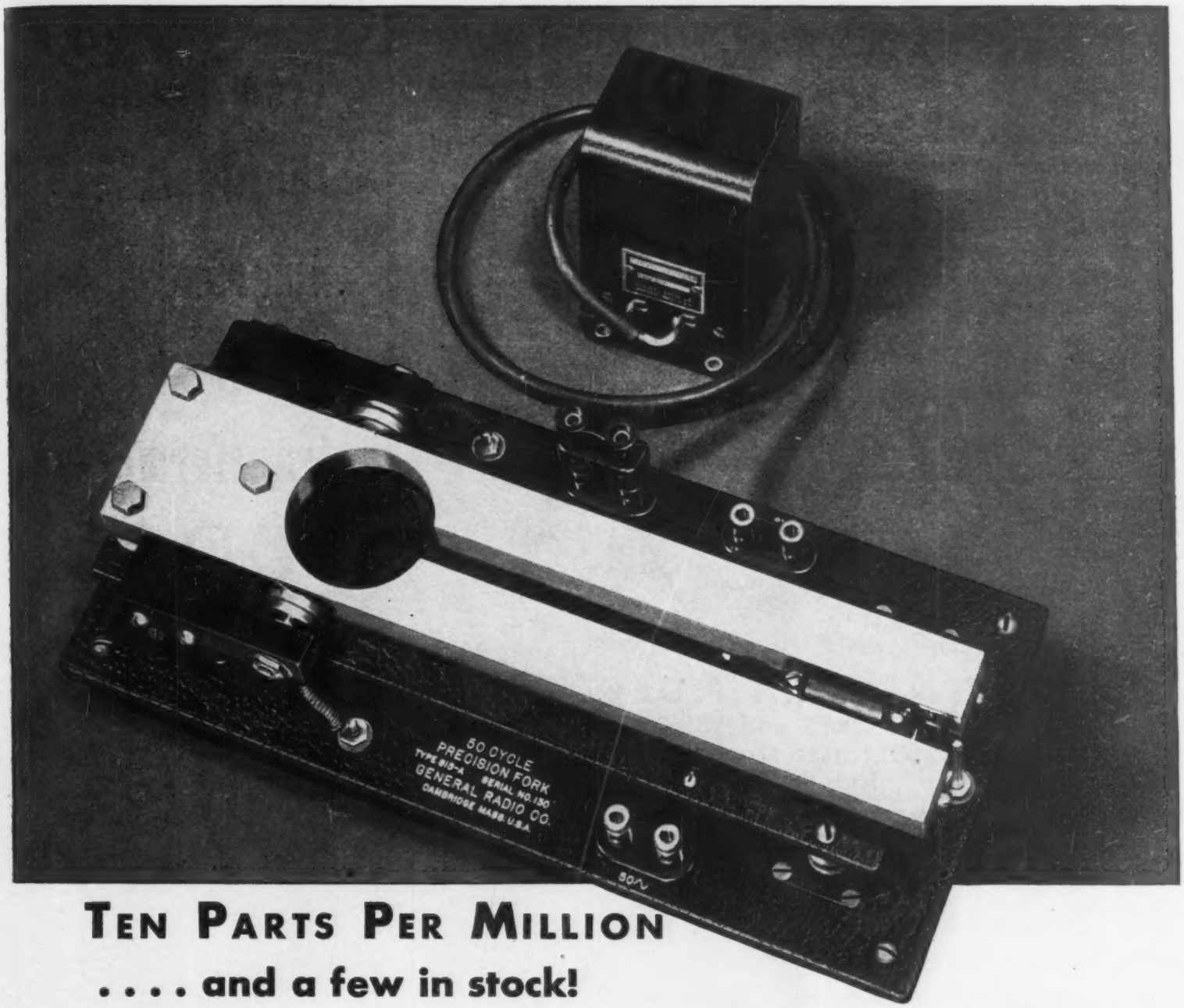
POTTER INSTRUMENT CO., 136-56 Roosevelt Ave., Flushing, N. Y. Four 4-tube decades are used in the Model 85 instrument that will respond to rates as high as 100 kilo-



cycles a second and scale them by factors as high as 10,000 to 1. Mainly designed for application in the fields of physics, medicine and chemistry, the equipment will undoubtedly find use in other fields where rapid counting is essential.

F-M Signal Generator

BOONTON RADIO CORP., Boonton, N. J. The type 202-B f-m signal generator covers the frequency range from 54 to 216 megacycles and provides two frequency devia-



TEN PARTS PER MILLION

. . . . and a few in stock!

Where the ultra refinement of temperature control is not required, the G-R Type 815 Precision Forks have more than sufficient accuracy for use both in the laboratory and in the field. They are supplied in frequencies of 50, 60 and 100 cycles with a calibration accuracy of ten parts per million. They make excellent low-frequency standards.

Stock for the forks is low-temperature-coefficient stainless steel, received by us in bars. A sample fork is made from each bar and the coefficient of the stock is obtained after a protracted temperature run.

The forks are then machined in our shops. When measured to one millicycle, the unmounted fork is about 2 cycles below its nominal frequency. After this initial measurement, the excess material is milled from the end of the tines and a second frequency check is made. Occasionally the forks must be milled a second time.

Two adjustable loading screws are placed in holes drilled and tapped in the end of each tine. The fork is then assembled and the temperature coefficient of the outer tine screw is obtained. If necessary, excess material is removed from the outer tine screw. The screws are adjusted so that the frequency is within $\pm 0.001\%$ of its nominal value. The voltage coefficient of frequency is obtained; it averages about 0.005%. Output voltage and harmonic content are then measured.

When orders are received the forks are returned to the standardizing laboratory, given a half-hour run and the frequency is measured at a driving voltage of exactly four volts. With each fork a calibration certificate is supplied to show: the frequency to within $\pm 0.001\%$ at a stated temperature between 70 and 80 deg. F.; the temperature and voltage coefficients of frequency.

TYPE 815-A	50-CYCLE FORK	$175.00
TYPE 815-B	60-CYCLE FORK	185.00
TYPE 815-C	100-CYCLE FORK	185.00
TYPE 815-P1	Transformer (for use between the fork and relatively high-impedance loads)	6.95

AT THE MOMENT WE HAVE A SMALL STOCK OF THESE FORKS

GENERAL RADIO COMPANY Cambridge 39, Massachusetts

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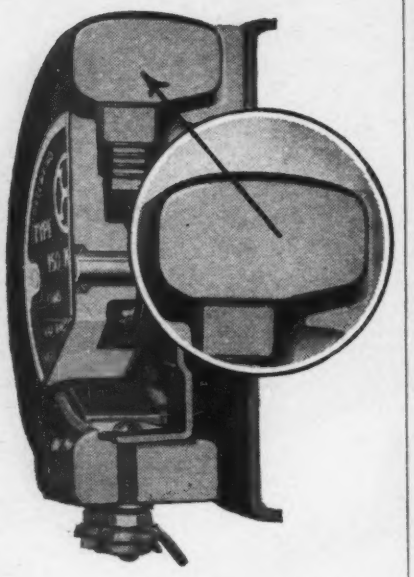
MASSIVE WINDING CORE
25% More Capacity

Another exclusive Hardwick-Hindle advantage is this great ceramic core of unusually large cross section for the wattage rating—*more* wire, *more* surface and, *less* temperature rise.

And between this ceramic winding core and the rugged die cast base there is ample space for full ventilation to insure low operating temperature for the mounting panel.

This is only one of several exclusive features. Let us tell you of other Hardwick-Hindle advantages in this and in other rheostats, as well as in our resistors.

Our engineering service is always available for specific problems. Write us today.



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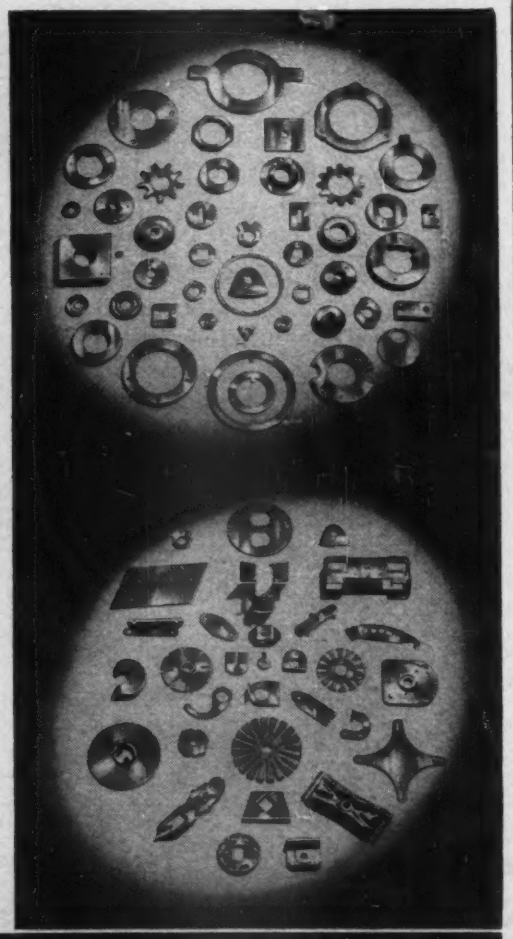

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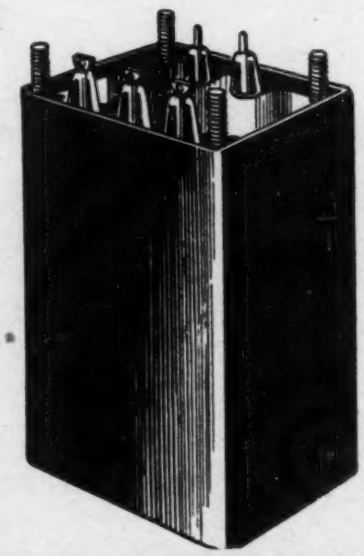

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CANNOT DISTORT!

"National" graphite has no melting point! It cannot melt or soften. This, plus the fact that graphite has a low coefficient of expansion and a high heat transfer rate, is the reason graphite will not warp or distort, regardless of operating temperature.

UNMATCHED THERMAL CONDUCTIVITY!

Because "National" graphite has a higher thermal conductivity than other anode materials, it provides greater protection from excess surface temperature — a cause of secondary or back electron emission. It also lessens the danger from local hot spots so often found in other anodes—the result of thin spots or concentrations of the electron stream.

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"National" graphite is almost an ideal black body, making it a nearly perfect heat radiator. Thus, anodes of "National" graphite operate at lower temperatures for a given amount of energy dissipated. All tube parts therefore operate at lower temperatures, resulting in less distortion of other parts and more uniform tube characteristics.

In addition... "National" graphite has exceptional purity...great strength...fine grain structure...high resistance to erosion...is a good conductor, especially at high frequencies...is free from dust and loosely held particles...provides low electron emission...and can be machined into intricate shapes to very close tolerances.

Yes...anodes of graphite have everything you need to turn out finer tubes. For more facts, write National Carbon Company, Inc., Dept. E.

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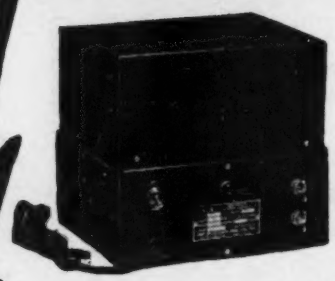

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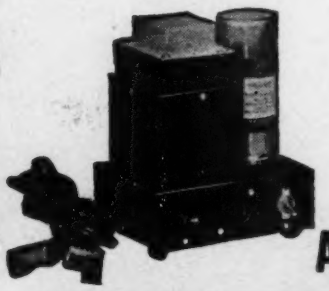

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Accurately detects sources of wear, strain and noise . . . . .

The TELEVISO MODEL 11-B VIBROMETER

● The Televiso Model 11-B Vibrometer electronically measures the vibration characteristics of any moving surface instantly and accurately. Unnecessary wear, strain and noise no longer need be tolerated in industrial machinery, and in the integral parts of products.

The Vibrometer is an invaluable design aid. It prevents breakdowns, locates trouble, speeds production, reduces rejects.

It is particularly useful in measuring the vibration in motors, gears, bearings, rotors, fans, propellers, presses, aircraft structures, stokers, etc. Ninety-five percent of all vibration measurements needed by industry are covered.

All three types of vibration are registered on a calibrated meter scale: *displacement,* where the vibration may be felt but not seen; *velocity,* where the vibration is minute; *acceleration,* where the vibrating surface is small.

Consisting of an integrated, amplified vacuum tube voltmeter with a cable-attached piezo-electric Rochelle salt crystal search prod; the Vibrometer is equipped with interchangeable fittings which permit innumerable applications.

Sturdily constructed and portable, the Vibrometer is practical for field, laboratory and production use. Operation is simple. Write today for complete technical data.

Specifications

Operation:	105-125 volt, 50-60 cycle, power.
Frequency Response with Search Prod Plugged in:	5-2500 cps., uniform within 2%. Correction graph to 2 cps. can be supplied.
Weight:	31 pounds.
Size:	17" high, 12" deep, 11½" wide, 10° slope.
Displacement Range:	5 ranges, 0-.01", 0-.03", 0-.1", 0-.3", 0-1" in RMS displacement.
Velocity Range:	5 ranges (in inches per second), 0-1, 0-3, 0-10, 0-30, 0-100.
Acceleration Range:	5 ranges (in inches per second per second), 0-100, 0-300, 0-1000, 0-3000, 0-10,000.
Output Jack:	Available at rear of Vibrometer for use with phones, oscillograph, wave analyzer, or recording devices.
Construction:	All aluminum mechanical components housed in a solid oak, copper lined cabinet. The black, wrinkle-finish panel is engraved.
Guaranty:	The Vibrometer is guaranteed for two years.

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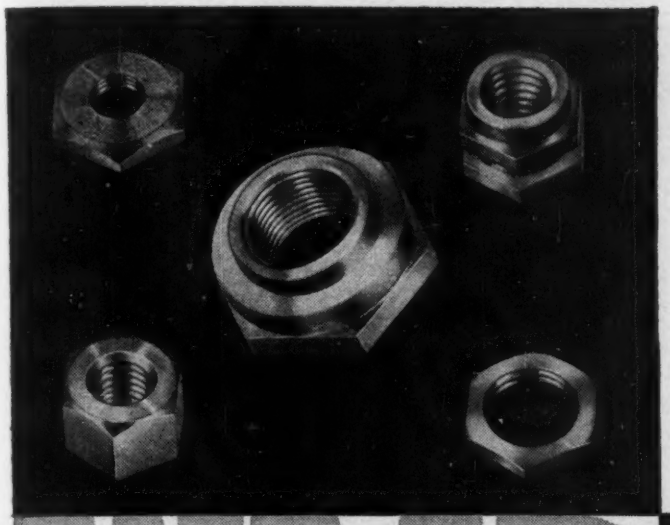

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SIGMA Type 41 RO (DC); 41 ROZ (AC)

NEW FEATURES OF THIS DESIGN:

- Fits octal socket.
- Outline dimensions: 1¼" x 1¼" x 2" above socket.

  Permits lining up contiguous relays as close together as the smallest octal sockets will permit.

Features of All SIGMA Series 41 Relays:

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- AC sensitivity: — 0.1 volt-ampere (min. input.)

  One standard 110 volt AC model draws about 1.5 milliampere.
- Contact ratings up to 15 amperes on low voltage.
- High quality construction — mechanically rugged.
- Very low cost.

SIGMA sales and engineering departments are ready to give your relay problems prompt analysis and action.

SIGMA

Sigma Instruments, INC.
Sensitive RELAYS
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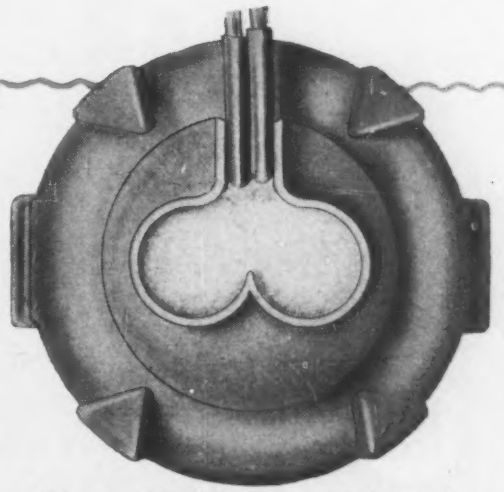
Fibron #5373
flexible plastic tubing

Here is another application where this improved Irvington formulation . . . Fibron #5373 . . . solves an electrical insulation problem involving high temperatures. Hot cement, used to seal the #5373-covered heating elements, has no effect on the flexibility of this unusual plastic. When the heater is in use, the tubing withstands continuous operating temperatures as high as 85° C. #5373 possesses the electrical, mechanical, and chemical properties which distinguish all Fibron tubings. Some of these are:

Dielectric Strength (.020" wall) wet..1000 V.P.M.
dry..1000 V.P.M.
Tensile Strength, P. S. I. 3000
Life at 105° C. .....2000 hours

Fibron #5373 tubing is available in all standard B & S wire gauge sizes, in six brilliant colors, in heavy wall thicknesses if required—in 36" lengths, coils, or cut pieces.

Test this unusual product now. Generous samples and additional technical information gladly sent on request.



**Approved by Underwriters' Laboratories for this application*

Short lengths of Fibron #5373 are used to protect the conductor leads on the heating element of the Electra-Serve, manufactured by Electrical Industries, Inc., Newark, N. J. This bottom view of the unit shows where the hot cement seals over the #5373 insulation. Withstanding this heat and high operating temperatures, #5373 tubing retains its flexibility and high dielectric strength.

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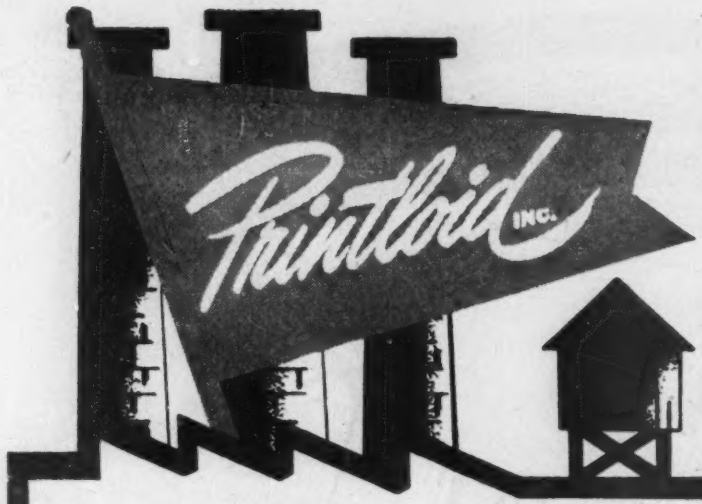

complete plastic display fabrication

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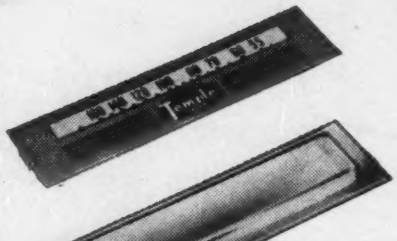

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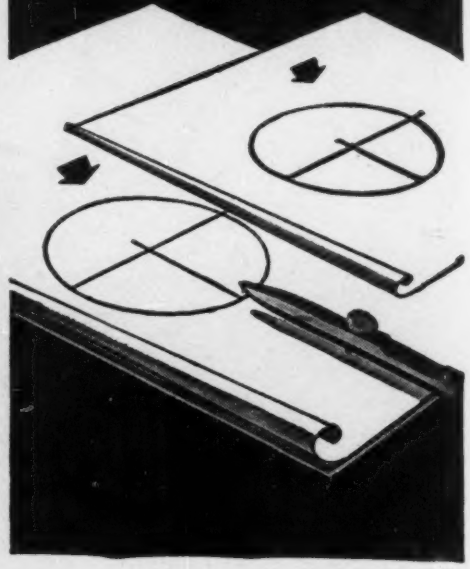

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SPEED NUTS prevent vibration loosening because they provide a *double* spring-tension lock that *absorbs* vibration instead of merely *resisting* it. Insures a tight attachment for the life of the product.

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In the assembly of porcelain enamel, plastic or glass parts, SPEED NUTS provide the tension necessary for a tight assembly, yet are sufficiently resilient to prevent damage due to expansion and contraction, vibration or shock.

PPLIED FASTER

SPEED NUTS put wings on your assembly lines because they start easier, pull down faster and no wrench is required to keep them from turning. Made also for use with coarse-thread sheet metal screws, requiring fewer turns to tighten, for still faster application.

LIMINATE LOCK WASHERS

You can boot lock washers out the window, for SPEED NUTS are self-locking. They cut both material and handling costs. Because of their wide bearing surface, SPEED NUTS also can eliminate the use of spanner washers.

SELF-RETAINING

Many types of SPEED NUTS lock themselves in screw-receiving position for "blind" location assembly, eliminating expensive welding, riveting or clinching operations.

PERFORM MULTIPLE FUNCTIONS

Like a one man band, many special types of SPEED NUTS perform multiple functions, replacing two or more parts. SPEED NUT prongs can be incorporated in almost any shape or form to do the job easier and faster.

LOCK ON UNTHREADED STUDS

"Push-On" SPEED NUTS need only be pushed over rivets, nails, tubing, or unthreaded studs to lock parts so securely, you can't wrestle them off. Costly threaded inserts, drilling and tapping are eliminated—molding costs reduced—assembly speeded up.

WILL NOT CLOG

Having no threads, SPEED NUTS cannot clog with paint. No assembly delay for re-tapping threads. This is particularly important where SPEED NUTS are permanently attached to parts for blind assembly.

WILL NOT "FREEZE" TO THREADS

Having no threads, SPEED NUTS will not "freeze" to rusting bolts. They can be easily removed at any time for servicing or replacing. You'll save the repair men a lot of cussing.

WEIGH LESS

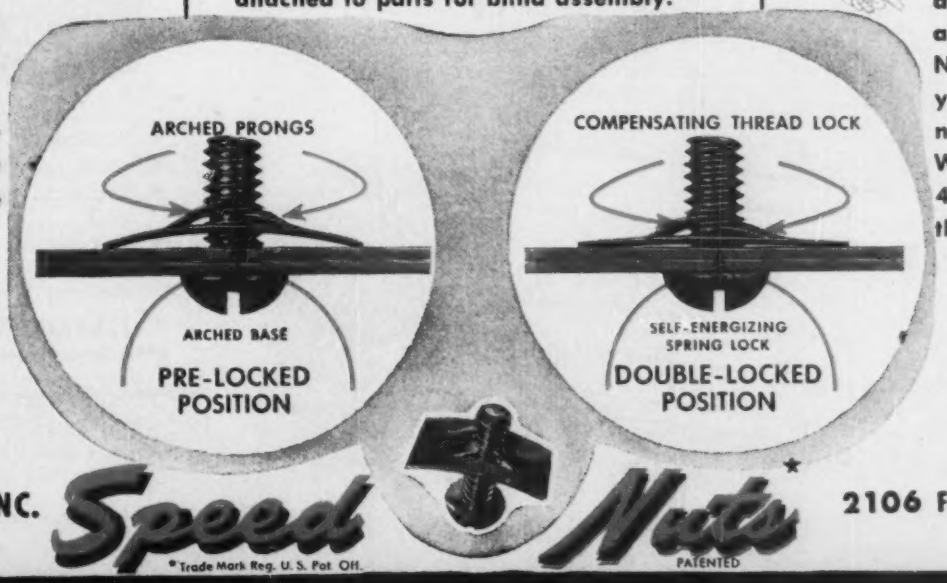
Because they are made of sheet metal instead of bar stock, SPEED NUTS are in the "featherweight" class compared with threaded nuts. By eliminating lock and spanner washers and other unnecessary parts, weight is reduced still further.

MINIMIZE SHIPPING DAMAGE

SPEED NUTS give you free insurance against shipping damage. They provide a resilient lock that defies loosening and prevents cracking of enamel and glass. With SPEED NUTS, your products will reach your customers in perfect condition.

SEND TODAY

We're not fooling about these advantages. They are very real and worth-while as any SPEED NUT user will tell you. Rush your assembly problems to us now, giving complete details. We'll show you which of the 4000 shapes and sizes will do the trick for you.



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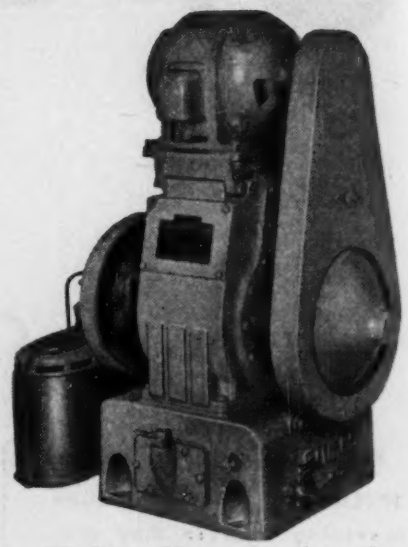

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(Patented McLeod Type)

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DIAMETER — ¾"

—made specifically for electronic relay applications...

Here's a new 3-element, inert-gas filled, internally triggered cold cathode relay tube designed for operation up to 1000 volts on the anode, with a positive pulse on the control or trigger grid—a tube made specifically for triggering.

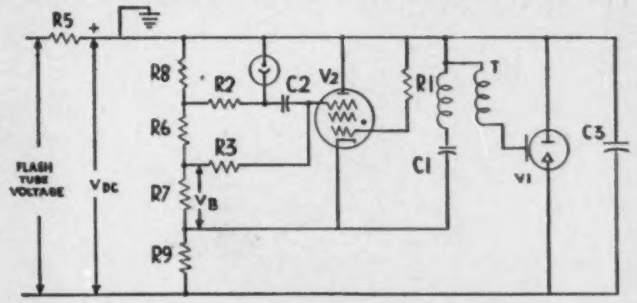
Its cathode structure is similar to that utilized in the well-known 1B21, SN4 type strobotron tubes which are mostly used for stroboscopic applications. This cathode design is characterized by its ability to furnish extremely high instantaneous peak currents—hundreds of amperes.

However, the design of the new Triggertube varies in that the delay time—time required to initiate the arc—as well as the deionization time, is greatly reduced as compared with previous triggering tubes. In addition, since this tube has been especially designed for trigger applications—applications which do not utilize the light flashes produced by the arc—it can be ideally utilized wherever stable characteristics and low switch current are important.

For example: electronic flash equipment in which externally triggered flash tubes can be readily controlled by a hand trip switch, built-in shutter synchronizing switches, or by a photocell.

Write address below for full specifications.

PHOTOCELL TRIPPING CIRCUIT FOR ELECTRONIC FLASH TUBE



R_1	Keep-alive current limiting resistor	20 megohms
R_2	Phototube resistor	0.25 megohm
R_3	Grid current limiting resistor	10 megohms
R_5	Power supply limiting resistor	
R_6, R_7, R_8, R_9	Phototube and Triggertube voltage divider	
C_1	Anode discharge condenser	0.25 μfd.
C_2	Trigger grid condenser	0.01 μfd.
C_3	Flash tube condenser	
T	Ignition coil condenser	
V_B	Trigger grid bias voltage	
V_1	Flash tube type R4330	
V_2	Type OA5 Triggertube	

The OA5 is licensed under the tube patents of Edgerton, Germeshausen and Grier, but no license is implied under their circuit patents.

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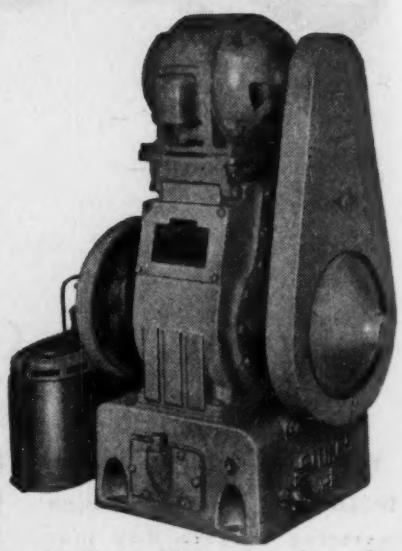

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It is a new 5-element, inert-gas filled, internally triggered cold cathode relay tube designed for operation up to 1000 volts on the anode, with a positive pulse on the control or trigger grid—a tube made specifically for triggering.

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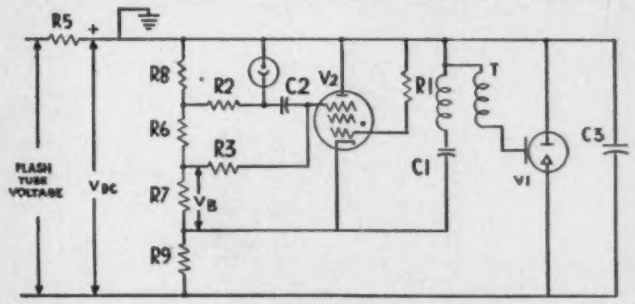
PHOTOCELL TRIPPING CIRCUIT FOR ELECTRONIC FLASH TUBE



R_1	Keep-alive current limiting resistor	20 megohms
R_2	Phototube resistor	0.25 megohm
R_3	Grid current limiting resistor	10 megohms
R_5	Power supply limiting resistor	
R_6, R_7, R_8, R_9	Phototube and Triggertube voltage divider	
C_1	Anode discharge condenser	0.25 μfd.
C_2	Trigger grid condenser	0.01 μfd.
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V_B	Trigger grid bias voltage	
V_1	Flash tube type R4330	
V_2	Type OA5 Triggertube	

The OA5 is licensed under the tube patents of Edgerton, Germeshausen and Grier, but no license is implied under their circuit patents.

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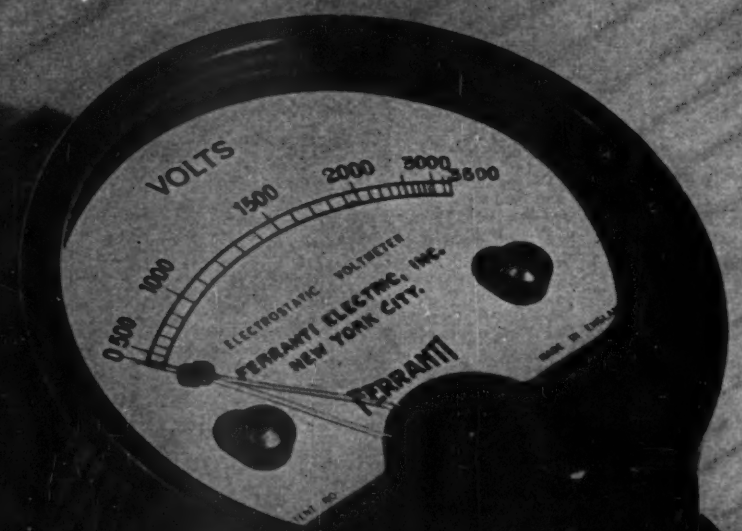

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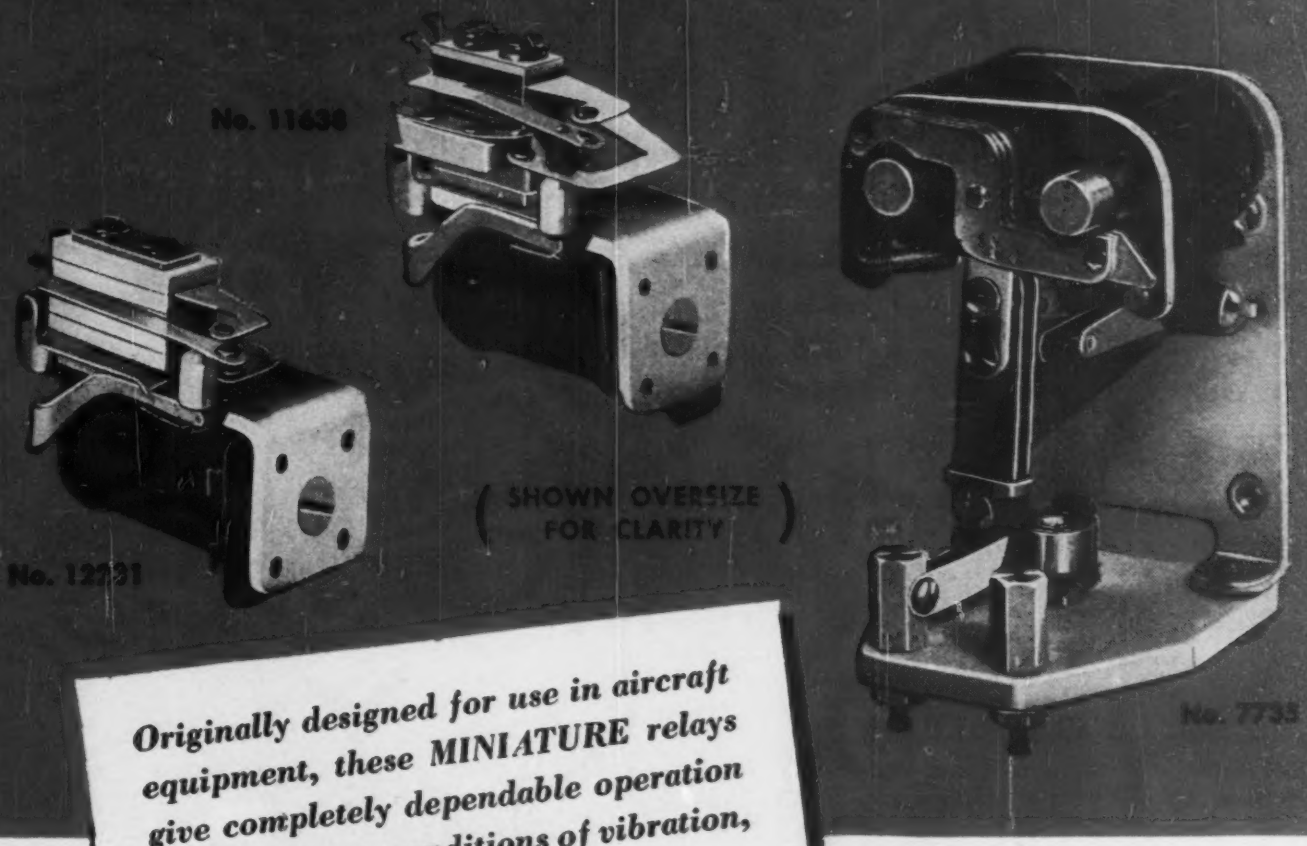

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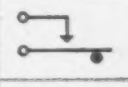
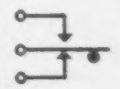
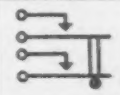
A.R.C. NO.	RATED D.C. OPERATING VOLTAGE	D.C. RESISTANCE	CONTACT ARRANGEMENT
11975	14	90	
12232	28	300	
11914	14	90	
12231	28	300	
11638	28	300	
7735	28	112	

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4 FACTORY-ADJUSTED SCREW
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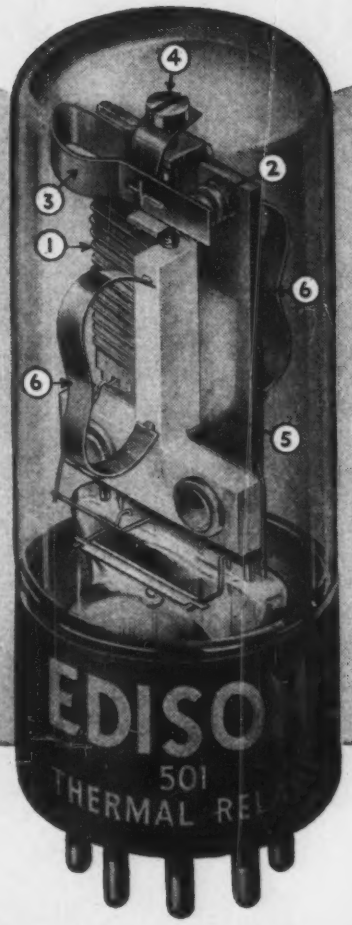

5 COMPENSATING BI-METAL
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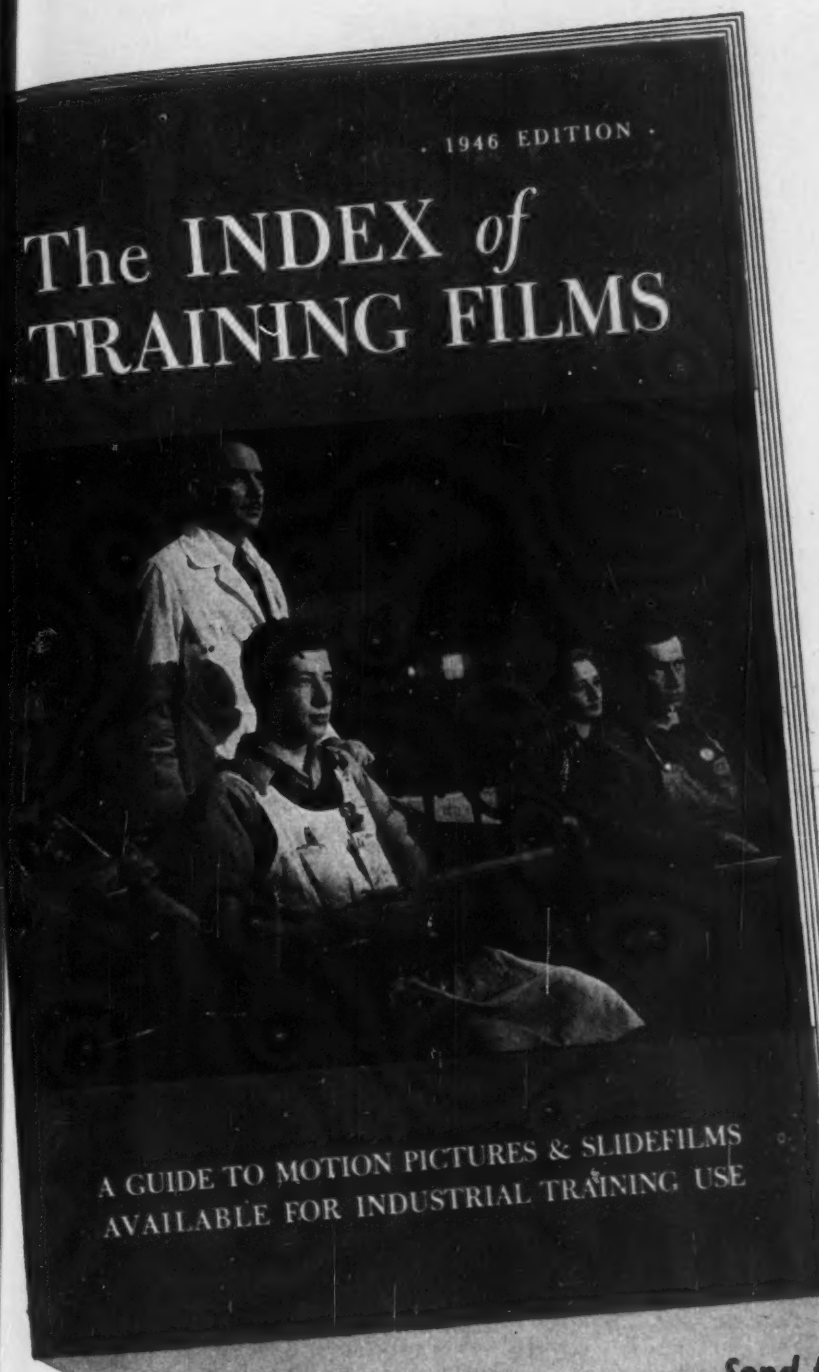

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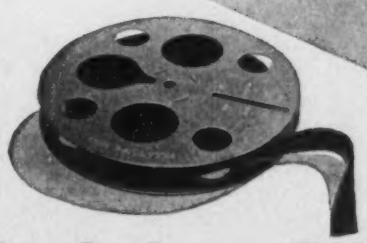

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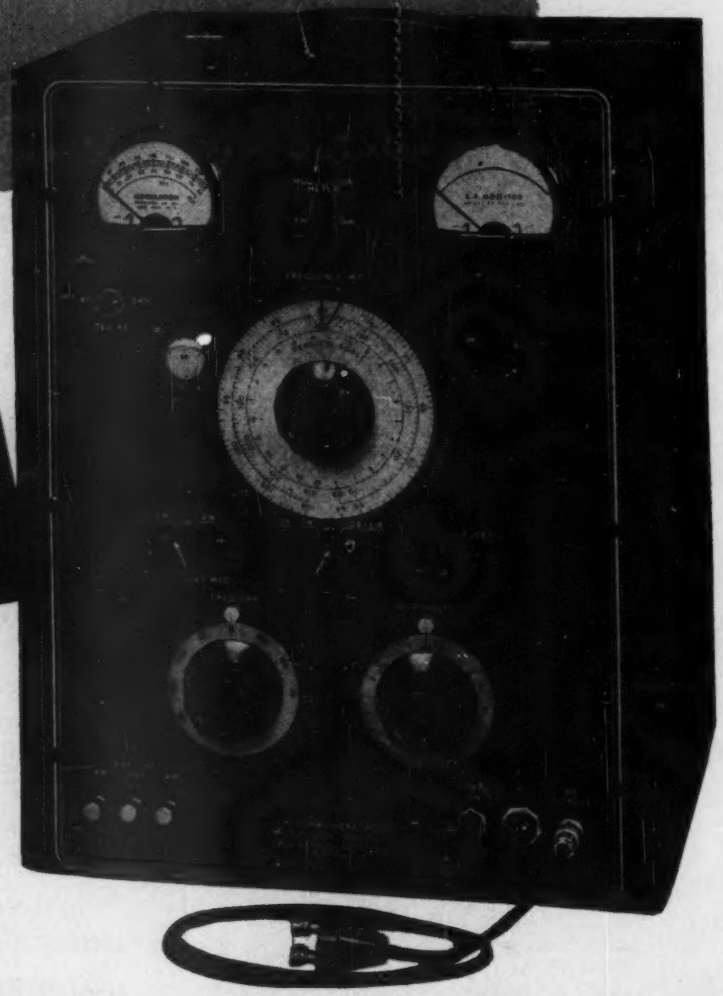

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The design of this instrument was described on pages 96-101 of the November issue of ELECTRONICS. Reprints of this article are available upon request.

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Company specializing in the development of electro-mechanical equipment has a permanent supervisory position open for Engineer—experience in electro-mechanical development and design.
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ASSOCIATE PROFESSOR Of Electrical Engineering. Education: M.S. degree in E.E. with specification in Electronics. Teaching experience required. Industrial or military experience desirable. Salary $3200.00 to $3600.00 for nine months school year depending on age and experience. Write: Department of Electrical Engineering, North Dakota Agricultural College, Fargo, North Dakota.

INSTRUCTORS to teach Radio Engineering, must have B.S. Degree in E. E. or Physics, or equivalent; 5 years experience in commercial electronics works. Knowledge of Microwaves desirable. Write giving full details regarding education and experience to Personnel Dept., Spartan School of Aeronautics, Tulsa, Oklahoma.

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SALARIED POSITIONS $2,500-$25,000. This thoroughly organized confidential service of 36 years' recognized standing and reputation carries on preliminary negotiations for supervisory, technical and executive positions of the calibre indicated, through a procedure individualized to each client's requirements. Retaining fee protected by refund provision. Identity covered and present position protected. Send only name and address for details. R. W. Bixby, Inc., 278 Dun Bldg., Buffalo 2, N. Y.

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SALES ENGINEER: Experienced engineer earnestly desires changing from dealing with circuits, slide rules and test apparatus to more direct contacts with people and personalities, i.e. position in sales engineering field. Thoroughly acquainted radio equipments and components; qualified from personality and appearance standpoints. Prefer N.Y.C. area or western U. S. PW-263, Electronics, 330 W. 42nd St., New York 18, N. Y.

(Continued on page 312)

WANTED

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Electronic Engineer, preferably under 30 years of age wanted for Research Department of Caterpillar Tractor Co., manufacturers of Diesel Engines, Tractors and earthmoving equipment. Applicant should be an Electrical Engineering graduate and have practical knowledge of laboratory electronic instrumentation, design and application.

Please state qualifications, education, training and experience so that an interview can be arranged.

All applications will be carefully considered and acknowledged. Please address:

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Prominent Aircraft Company, Eastern United States needs men with following qualifications:

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JANUARY 1, 1947
Executive
Electronics Engineer

RESEARCHER—DESIGNER

Age 41, married, 3 children.
Salary $10,000-$12,000, any place in U.S.A.

Lt. Comdr. USNR, released April 28, 1946
Sole inventor 18 patents, including 1806738, 2077768, 2089575, 2102911, 2106410, 2164019, 2168071, 2346868, 2358534. Co-inventor others.
For 15 years, Chief E.E. in charge Res. & Dev., midwest manufacturer speed-control systems.
Weak at calculus and chemistry; strong at mechanics, electronic circuitry, servo-mechanism, instrumentation, design for production.
Worked on development Night-Fighter Radar at M.I.T.; then Aircraft Radar Officer on carrier in combat; then 18 mo. BuAer, Armament Division, developing systems for combining Radar with Fire-Control, Turret-Control, and Bomb-sights.
Continuously retained since, "Consulting" on product development and market survey. Successful at Sales Engineering and at getting along with people. Prefer to accept the lower pay that goes with security, research, and less necessity to "win friends and influence people."

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We need a top-flight executive to direct the engineering efforts of our young, expanding electronic manufacturing organization.

P-267, Electronics
330 West 42nd St., New York 18, N. Y.

Additional Employment Advertising on Pages 312 & 313

WANTED

PHYSICISTS

Large Oil Company in the East with long established Research and Development Division has openings for men with experience in experimental or theoretical physics.

A rapidly growing physical research group is doing fundamental and applied research in radiation, nuclear, electronics, general physics, and geophysical prospecting.

Real opportunities exist for top flight men to grow with this expanding organization which is committed to long term research.

Salaries are high and based on education and experience. Our own personnel know of this ad.

P-227, Electronics
330 West 42nd St., New York 18, N. Y.

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Broadcast Radio receiver Project Engineers, Television receiver Project Engineers and Mechanical Engineers experienced in broadcast receiver engineering methods. Excellent opportunity for advancement in a growing engineering department.

Reply giving full details to

Personnel Manager
BENDIX RADIO
Division of Bendix
Aviation Corporation
Baltimore 4, Maryland

Aircraft Corporation, old established firm has openings for the following technical personnel:
Engineering Technical Writer—B S Degree in Aero Engr. or Mech. Eng. Experience in report writing necessary.
Industrial Engineer—25 to 30 years old with 3 to 5 years experience in Administrative Engineering with Industrial Organization.
Two Electrical Engineers or Physicists, M S Degrees or better preferred. One with at least four years experience in research or development of television or microwave receivers, the other with equivalent experience on microwave antennas and/or systems.
Two Applied Physicists—M S or Ph D Degrees, one with at least 3 years experience in Electronics and/or Instrument Design, the other with equivalent experience as an experimental physicist with high vacuum experience.
Two Mathematicians—M S or Ph D Degree with five years experience in Research and Development Problems.

P-261, Electronics
520 North Michigan Ave., Chicago 11, Ill.

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Applicants should be acquainted with Electronic circuits and will first spend considerable time at factory to study equipment.

RW-259, Electronics
520 North Michigan Ave., Chicago 11, Ill.

POSITIONS WANTED

(Continued from page 311)

QUALIFIED RADIO Engineer desires connection as Assistant Chief Engineer, Administrative, Project, Liaison, Sales Engineer or equivalent responsible position. Prefer television or UHF/VHF activities. Eight years background research, developmental, production phases auto radios, RF coil and tuner design, FM, radar countermeasures, D/F systems, recording-reproducing equipment. Age 31; married; personable; ability to direct overall responsibilities of developmental and production projects. Location N.Y.C. area or western U.S. PW-264, Electronics, 330 W. 42nd St., New York 18, N. Y.

ELECTRONICS TRAINEE on job preferred. 3 years experience with U. S. Navy. Eric Browner, 3132 Perry Ave., Bronx, New York. Telephone: Olinville 2-2144.

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LOUDSPEAKER for custom and domestic sound installations (see Electronics for February, 1946) with performance comparable to large theater types now developed through pilot model and limited production stages including patent protection, needs plant, market development and organization beyond my means. Would consider forming, joining, or being joined by existing organization or individuals to form team to exploit this and other ideas. Write: Paul W. Klipsch, Hope, Arkansas.

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by large radio parts manufacturer

Will be trained for territorial office managementships. Good appearance, pleasant personality and desire to learn overall sales and business management are essential, but none need apply who lack the prime requisite of practical broadcast receiver design engineering experience. In reply give historical background, nationality and salary requirement.

SW-231, Electronics
330 West 42nd St., New York 18, N. Y.

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Experienced engineers with Bachelor's, Master's or Doctor's degrees in Electrical Engineering, Communications, Radio, Physics, Mathematics. At least two years experience in design and development of radar and television systems, electronic navigational systems, automatic computers, servomechanisms, etc., required.

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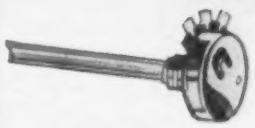

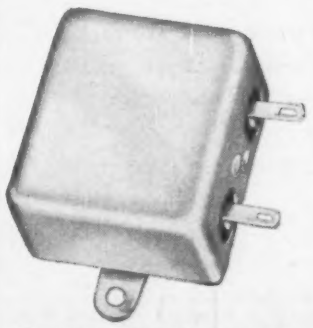

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10—7½ KVA Air Cooled, Completely enclosed Transformers; primary 220/440 Volts, 60 cycles, 3 phase (12 terminals); secondary 3240/5600 Y volts with taps at 2440/4230 Y volts (7 terminals including neutral). *Dielectric test* — 2000 volts from primary to ground. 16000 volts minimum from secondary to primary and secondary to ground.

Brand new, immediately available, attractively priced.

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Made by North American Philips

Tube	Type	Approx. List	Your Cost
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5JP2		48.00	13.50
	HI POWER XMTR TUBES		
837		2.80	1.50
872A		7.50	3.50
705A		22.50	7.50
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Broadcast band Push-button tuning units inductive, capacitive types.	2.98
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POWER SUPPLY for LM-18 freq. meter. Output: 200v @ 20 ma; 13v @ 600 ma. Input: 105-125v @ 60 cps; 260 ma; 27.6 W. with type 84 rectifier tube; shock mounted. Complete with input and output plugs. $14.75

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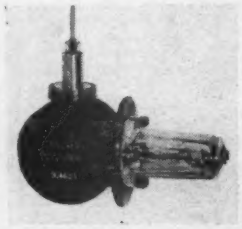

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KLYSTRON oscillator tubes. 2K25/723-ab. designed for 3 cm. operation. New. Packed individually. Listed at $38.00. OUR PRICE $7.75

30 MC I.F. AMPLIFIER with 2-6AC7's. Uses 723 a/b. 3 CM wave guide input. 21 IN XTAL Detector with 6AC7 Tubes $10.00

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D. 90° bend in wave guide 15" long also 90° bend in coupler	@ 6.50
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C. 150° bend, with 90° twist 3½" radius with pressurizing nipple and coax coupler	@ 3.95

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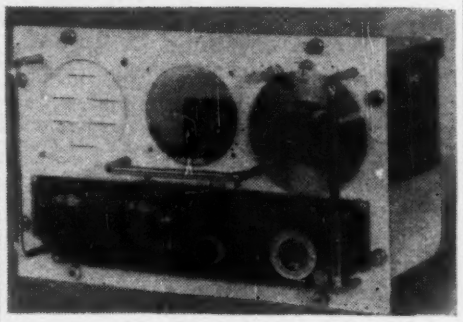

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1—Power Transformer, 115 volt 60 cycle input, output 315-O-315 volts at 70 MA, 6.3 volts center tapped at 3.5 ampere, 5 volt at 3 ampere

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1—3 deck, 2 pole, 5 position each wafer switch.

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The unit was designed to use 1,6SJ7; 1,6SN76T; 1,6U66T; 1-5Y36T; 1,UR-150/30

NO TUBES SUPPLIED WITH UNIT

Has a large quantity of assorted resistors, mica condensers, bathtub condensers, potentiometer, connectors, etc.

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MICROAMMETERS, GALVONOMETERS

McClintock, 3½" square, 0-50 ua mvt., spec. scale.....$4.50
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Weston 3½", 0-1000 M.A.....$4.50

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W.H., SX-33, 2½", Sur. Mtd., 3-03 V, 200 r/v.....$1.25
Western Electric, 3½", Concentric Style, 0-75 volt D.C., 1000 r/v...$3.00
Gruen, 2½", 150 volt.....$3.50
W.H., NX-35, 3½", 0-200 V, 1000 r/v $5.50
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W.E., 3½", 500 volt, 1000 r/v Concentric Style.....$5.00
Weston 301, 3½", 0-4 KV with ext prec resist $7.95
W.H., NX-35, 3½", 15 K.V. comp. with 1000 r/v ext prec resist L.P. $160.00
Your Cost $16.00
W.H., NX-35, 3½", 20 K.V. comp with 100 r/v ext prec resist L.P.$210.00
Your cost $21.00

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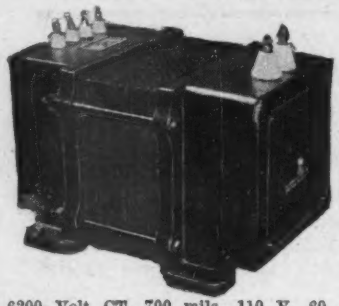

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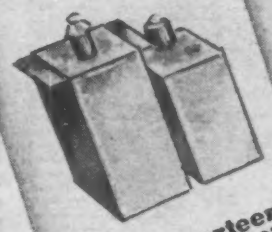

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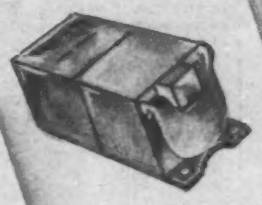

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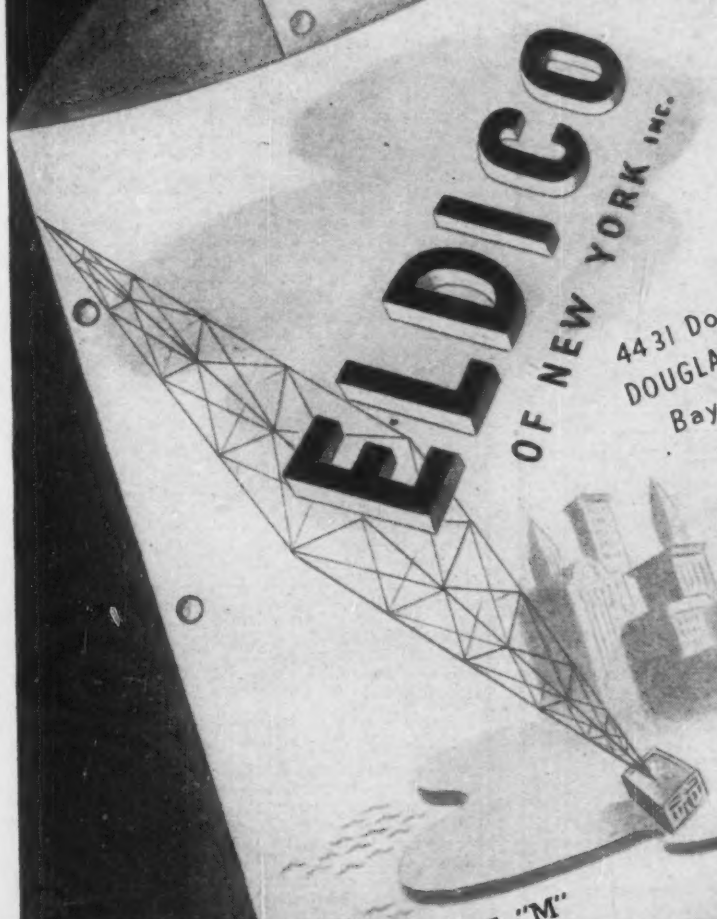

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INDEX TO ADVERTISERS

	Page
Acheson Colloids Corporation	3
Acro Electric Co.	262
Acton Co., Inc., H. W.	274
Adams & Westlake Company	66
Advance Electric & Relay Co.	286
Aerovox Corporation	68
Aircraft-Marine Products, Inc.	30
Aircraft Radio Corporation	179
Allen Mfg. Co.	260
Alliance Manufacturing Co.	79
Allied Radio Corporation	284
Allied Recording Products Co.	276
Allmetal Screw Products Co.	283
Alni Corporation	306
Altec Lansing Corporation	235
Alden Products Co.	309
American Brass Co., American Metal Hose Branch	248
American Electrical Heater Co.	256
American Lava Corporation	69
American Phenolic Corp.	227
American Platinum Works	297
American Precision Dial Co.	275
American Rolling Mill Co.	243
American Screw Company	36
American Television & Radio Co.	200
American Time Products, Inc.	144
Amperex Electronic Corporation	Inside Front Cover
Amperite Company	262
Andrew Co.	216
Ansonia Electrical Div. of Noma Electric Corp.	14
Arkwright Finishing Co.	170
Arnold Engineering Co.	178
Art Wire & Stamping Co.	301
Astatic Corporation	242
Atlas Sound Corp.	296
Audak Company	319
Audio Development Co.	226
Audio Devices, Inc.	17
Automatic Mfg. Corporation	161
Automatic Signal Div. Eastern Industries, Inc.	208
Baer Co., N. S.	294
Bakelite Corp.	57
Ballantine Laboratories, Inc.	174
Barker & Williamson	292
Belden Manufacturing Co.	215
Bell Telephone Laboratories	28, 29
Bentley, Harris Mfg. Co.	18
Bird Electronic Corporation	301
Blan	303
Bliley Electric Co.	173
Boonton Radio Corporation	168
Bradley Laboratories, Inc.	292, 299
Bruning Co., Inc., Charles	229
Bud Radio, Inc.	266
Burgess Battery Co.	297
Burke Electric Co.	303
Burndy Engineering Co., Inc.	300
Burnell & Company	287
Burstein-Applebee Co.	309
Callite Tungsten Corporation	54
Cambridge Thermionic Corporation	290
Cannon Electric Development Co.	244
Capitol Radio Engineering Institute	252
Carter Radio Div., Precision Parts Co.	305
Celanese Corp. of America	177
Central Paper Co., Inc.	264
Centralab, Div. of Globe-Union, Inc.	72
Chatham Electronics	70
Chicago Metal Hose Corp.	232
Chicago Transformer Co.	45
Cinch Manufacturing Corporation	137
Clare and Co., C. P.	35
Clarostat Mfg. Co., Inc.	302
Clippard Instrument Laboratory, Inc.	309
Cohn & Co., Sigmund	256
Colgate Mfg. Corp.	223
Collins Radio Company	63
Communication Measurements Laboratory	234
Concord Radio Corporation	277
Condenser Products Co.	253
Continental Diamond Fibre Co.	181
Cornell-Dubilier Electric Corp.	15
Cornish Wire Company, Inc.	202
Coto-Coil Co., Inc.	218
Cross Co., H.	309
Cryscon, Inc., Sub. of Crystal Research Lab's, Inc.	294
Dalmo Victor	165
Daven Company	Inside Back Cover
De Mornay Budd, Inc.	237
Deutschmann Corporation, Tobe	6
Dial Light Co. of America, Inc.	274
Drake Electric Works, Inc.	276
Drake Mfg. Co.	264
Driver-Harris Company	24
Dumont Electric Corporation	34
Dumont Laboratories, Inc., Allen B.	26
Durez Plastics & Chemicals, Inc.	145
Eastern Air Devices, Inc.	11
Eastman Kodak Company	167
Eby, Inc., Hugh H.	205
Edison, Inc., Thomas A., Instrument Div.	172
Editors and Engineers, Ltd.	309
Eisler Engineering Co.	283, 309
Eitel-McCullough, Inc.	25
Electric Indicator Co.	299
Electrical Insulation Co., Inc.	200
Electronic Engineering Co., Inc.	303
Electronic Mechanics, Inc.	171
Electronic Specialties Mfg. Co.	293
Electrons, Inc.	154
Engineering Co.	278
Erco Radio Labs, Inc.	230
Erie Resistor Corporation	58
Essex Wire Corporation	24
Essex Electronics	318
Farnsworth Television & Radio Corp.	259
Federal Tel. & Radio Corp.	221
Felsenthal & Sons, G.	220
Fenwal, Inc.	185
Ferranti Electric, Inc.	184
Finch Telecommunications, Inc.	190
Fish-Schurman Corporation	305
Formica Insulation Co.	169
Franklin Airloop Corporation	159
Franklin Mfg. Corp., A. W.	43
Furst Electronics	293
Garrard Sales Corp.	245
Garrett Co., Inc., George K.	241
Gear Specialties	73
General Cement Mfg. Co.	309
General Electric Co.	
Apparatus Dept.	27, 48, 49, 200
Appliance & Merchandise Dept.	273
Chemical Dept.	175, 197
Electronics Department	78, 255, 289, 304
Lamp Dept.	164
General Industries Co.	150
General Magnetic Corporation	299
General Plate Div. of Metals & Controls Corp.	60
General Radio Company	203
Goat Metal Stampings, Inc.	276
Goodrich Chemical Co., B. F.	324
Gould-Moody Co.	290
Gramer Co.	188
Graphite Metallizing Corp.	266
Graybar Electric Co.	268
Guardian Electric Mfg. Co.	141
Hallicrafters Company	65
Hammarlund Mfg. Co., Inc.	10
Hardwick, Hindle, Inc.	204
Harvey Radio Company	260
Hathaway Instrument Co.	258
Haydon Manufacturing Co., Inc.	186
Heinemann Electric Co.	155
Helipot Corporation	271
Hewlett-Packard Company	67
Hexacon Electric Co.	146
Hudson Wire Co.	196
Hytron Radio & Electronics Corp.	56
Imperial Tracing Cloth	192
Indiana Steel Products Co.	239
Institute of Radio Engineers	285
Instrument Electronics	288
Instrument Resistors Co.	268
Insulation Manufacturers Corp.	296
Insuline Corporation of America	246
International Nickel Co., Inc.	251
International Resistance Co.	143
Interstate Mfg. Corp.	228
Irvington Varnish & Insulator Co.	191
Jelliff Mfg. Corp., C. O.	291
Jensen Manufacturing Co.	59
Johnson Co., E. F.	77
Jones Div., Howard B., Cinch Mfg. Co.	287
Kahle Engineering Co.	309
Karp Metal Products Co., Inc.	41
Kay Electric Co.	295
Kenyon Transformer Co., Inc.	152
Kester Solder Co.	224
Keuffel & Esser Co.	3
Kirkland Co., H. R.	293
Kwikheat Div., Sound Equipment Corp.	286

INDEX TO ADVERTISERS

	Page
Lampkin Laboratories	309
Langevin Company	287
Lapp Insulator Co,, Inc.	46, 47
Lavoie Laboratories	281
Linde Air Products Company	201
Lord Manufacturing Company	211
Macallen Company	212
Machlett Laboratories, Inc.	37
Magnavox Co.	267
Magnecord, Inc.	279
Maguire Industries, Inc.	81
Makepeace Company, D. E.	156
Mallory & Co., Inc., P. R.	82, 139
MB Manufacturing Co., Inc.	38
McGraw-Hill Book Co.	306
Measurements Corporation	284
Mepham Corp., G. S.	297
Meyercord Company	257
Mica Insulator Co.	8, 9
Micro Switch Corp.	50, 51
Midwest Molding & Mfg. Co.	287
Miles Reproducer Co., Inc.	309
Milford Rivet & Machine Co.	194
Millen Mfg. Co., Inc., James	254
Minnesota Mining & Mfg. Co.	149
Mitchell-Rand Insulation Co., Inc.	64
Monsanto Chemical Co., Plastics Div.	5
Multi-Products Tool Company	19
National Carbon Co., Inc.	199
National Company, Inc.	193
National Radio Service Co.	206
National Research Corporation	44
National Schools	272
National Varnished Products Corporation	209
Newark Electric Co., Inc.	188
New England Screw Co.	288
Niagara Radio & Supply Co.	295
Northern Communications Mfg. Co.	300
Northern Industrial Chemical Co.	283
Ohio Electric Mfg. Co.	210
Ohmite Mfg. Co.	16A, 16B
Onan & Sons, D. W.	258
Paramount Paper Tube Corp.	291
Par-Metal Products Corporation	285
Petersen Radio Co.	278
Phillips Screw Manufacturers	247
Portable Products Corp., Paul and Beekman Div.	62
Potter Instrument Co.	305
Precise Electronics Co.	309
Premax Products	278
Press Wireless Manufacturing Corp.	12, 13
Printloid, Inc.	192
Progressive Mfg. Co.	285
Quadriga Manufacturing Co.	295
Quaker City Gear Works, Inc.	222
Radio Corp. of America, Victor Div.	32, 76, Back Cover
Radio Frequency Labs, Inc.	61
Radio Receptor Co., Inc.	74
Radio Supply & Engineering Co., Inc.	298
Radionic Equipment Co.	288
Railway Express Agency, Air Express Div.	166
Rauland Corporation	151
Rawson Electrical Instrument Co.	303
Raytheon Mfg. Co.	55, 288
Reeves Soundcraft Corp.	254
Revere Copper & Brass, Inc.	16
Rex Rheostat Co.	309
Richardson Company	53
Rockbestos Products Corp.	269
Roller-Smith Co.	153
Rowe Industries	291
Rubicon Company	298
Ruby Chemical Co.	274
Sangamo Electric Company	180
Scientific Electric Div. of "S" Corrugated Quenched Gap Co.	40
Scovill Mfg. Co., Waterville Screw Products Div.	147
Seeburg Corporation, J. P.	22
Segel Co., Henry P.	274
Selenium Corp. of America	233
Shallcross Mfg. Co.	162
Sherron Electronics Co.	39
Shure Brothers, Inc.	158
Sigma Instruments Inc.	196
Sillcocks-Miller Co.	270
Simpson Electric Co.	225
Sola Electric Company	75
Solar Mfg. Corp.	80
Sorensen & Company, Inc.	250
Sound Apparatus Co.	291
Speer Carbon Co.	148
Sperry Gyroscope Co., Inc.	219
Sprague Electric Co.	249
Stackpole Carbon Company	207
Stamford Metal Specialty Co.	303
Standard Arcturus Corp.	293
Star Expansion Products Co., Inc.	299
Star Porcelain Company	285
Sta-Warm Electric Co.	278
Stevens-Walden, Inc.	302
Steward Mfg. Co., D. M.	305
Stokes Machine Co., F. J.	188
Struthers-Dunn, Inc.	4
Stupakoff Ceramic & Mfg. Co.	20, 21
Sun Radio & Electronics Co., Inc.	309
Superior Electric Co.	176
Superior Tube Company	263
Sylvania Electric Products, Inc., Electronics Div.	183
Tech Laboratories	276
Techlit Consultants, Inc.	213
Televiso Products Co.	195
Thermador Electrical Mfg. Co.	204
Thomas & Skinner Steel Products Co.	303
Tinnerman Products, Inc.	187
Triplett Electrical Instrument Co.	287
Tung-Sol Lamp Works, Inc.	265
Turner Co.	217
Union Carbide & Carbon Corp.	57, 199, 201
United Electronics Co.	42
United Transformer Corp.	2
Victoreen Instrument Co.	270
Voigt Patents, Ltd.	208
Vulcan Electric Co.	301
Waldes Kohinoor, Inc.	163
Walter Co., S.	272
Ward Leonard Electric Co.	160
Webster Electric Co.	182
Weller Mfg. Co.	208
Western Electric Co.	28, 29, 268
Westfield Metal Products Co., Inc.	196
Weston Electrical Instrument Corp.	52
Whistler & Sons, Inc., S. B.	7
White Dental Mfg. Co., S. S.	261, 295
Whitehead Stamping Co.	297
Wilcox Electric Co., Inc.	157
Wilson Co., H. A.	189
Wrought Washer Mfg. Co.	204
Zophar Mills, Inc.	192
PROFESSIONAL SERVICES	310

SEARCHLIGHT SECTION

(Classified Advertising)

BUSINESS OPPORTUNITIES	312
EMPLOYMENT	312, 312, 313
REPAIRING	313
SPECIAL SERVICES	313
WANTED TO PURCHASE	313
USED EQUIPMENT	313-317
Advance Transformer Co.	313
American Electric Sales Co., Inc.	316
Browning Lab. Inc.	316
Columbian Rope Co.	316
Communication Equipment Co.	314
D-D Supply Co.	316
Eldico of N. Y. Inc.	317
Electro-Tech. Equipment Co.	313
Electro Impulse Lab.	316
General Transformer Corp.	316
Marcus Transformer Co., Inc.	313
Maritime Switchboard	314, 315
New England Transformer Corp.	313
Niagara Radio Supply Corp.	316
Remler Co., Ltd.	314
Tab	316
Wells Sales, Inc.	313

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A

Acoustic trends, war influence on. H. S. Knowles ..... Jan. *246
Adhesives for r-f heating, resin..... Dec. *202
Alarm systems for panoramic receivers. W. A. Anderson..... July *92
Alloys, sorting. N. F. Agnew..... Sept. *124
Altimeter, f-m radar..... Apr. *130
Altimeter, pulse-type radio. Albert Goldman ..... June *116
American Institute of Electrical Engineers Winter convention..... Apr. *230
Ammeter, remote indicating antenna. C. R. Cox..... Jan. *210
Amplifier, cathode-coupled isolating, Earle Travis ..... Jan. *202
Amplifier, compensating. C. N. Gillespie ..... Mar. *232
Amplifier, direct-coupled r-f. Earle Travis ..... Dec. *154
Amplifiers for aircraft, isolation. G. F. Rogers ..... Aug. *122
Amplifier for f-m monitoring, bridging. G. E. Begg, Jr..... Jan. *152
Amplifiers, grounded-grid power. E. E. Spitzer ..... Apr. *138
Amplifier, reentrant pentode a-f. Robert Adler ..... June *123
Amplifier, telephone. H. K. Van Jepmond ..... Mar. *139
Amplifier tube, wideband microwave. Nov. *90
Amplifiers, wide-band ..... June 230
Amplifiers, wideband i-f..... Dec. *232
Antennas for circularly polarized waves. Dec. *214
Antenna for trains, VHF. E. G. Hills ..... Nov. *134
Antenna, low impedance loop, for broadcast receivers. L. O. Vladmir.... Sept. *100
Antenna meter, clip-on ..... Sept. *158
Antenna system, two-station. Lindsay McManus ..... Nov. *154
Antenna type for f-m and facsimile, new ..... Feb. *204
Atomic bombs, measurement of ocean waves generated by. N. J. Holter.. May *94
Atomic bomb production, x-ray snapshots used in ..... Jan. *164
Audio and video on one carrier..... Apr. *208
Auditory perception. Goodell & Michel, July *142
Aurora and geomagnetism. C. W. Gartlein ..... Jan. 242
Automobile engines tested..... Nov. *178
Aviation, ground-controlled approach for control of commercial..... May 160

B

Beat-frequency interference chart. Don Barton ..... Apr. *162
Betatron pulsing system. Paul & Wang. Jan. *156
Bibliography of important books. June 15–239
Bikini electronics. Fink & Engleman. Nov. *84
Blind, photoelectric aid for the..... Jan. *204
Blind, reading aid for the. Zworykin & Flory ..... Aug. *84
Blind, sensory aid for the. Lawrence Cranberg ..... Mar. *116
Broadcast frequencies, measuring and monitoring. L. S. Cole..... July *110
Butterfly circuits, coaxial. E. E. Gross, Jr. ..... Apr. *156
Butterfly circuit, coaxial modification of the. E. E. Gross..... Jan. *222
Buyers' guide ..... June 15 D-1
Buyers' guide additions and corrections. Nov. 217
Buzzer signal generator for 3,000 mc. Oct. *140
Bypass for measuring purposes, electronic. Dr. L. A. Finzi..... Feb. *196

C

Cable, measurement of velocity of propagation in. Kramer & Stolte..... July *128
Calling system, selective. J. K. Kulansky ..... June *96
Capacitors, improved. ..... June 218
Cascade phase shift modulator. M. Marks ..... Dec. *104
Cathode follower. ..... Aug. *204
Cathode follower coupling in d-c amplifiers. L. P. Yu ..... Aug. *99
Cathode follower of low output resistance ..... Nov. *206
Cathodes, oxide coated..... Dec. *226
Cathode ray tube, double-beam, in biological research. T. H. Bullock .. July *103
Cathode ray tube production, streamlining. M. Silverman..... July *164
Cavities, apertures in. J. H. O. Harries ..... Dec. *132
Cavities, stabilized..... June 234
Circuits, constant current Wheeler & Fundingsland ..... Nov. *130
Circuits, linear sweep. R. P. Owen.. Dec. *136
Circuits, printed electronic. Brunetti & Khouri ..... Apr. *104
Coaxial cables, solid dielectric.. June 15-86
Coaxial lines, design data for beaded. C. R. Cox..... May *130
Code translator, electronic. H. W. Babcock ..... June *120
Coils, mutual inductance of concentric. T. C. Blow ..... Nov. *138
Coils, wire length of universal. A. W. Simon ..... Mar. *162
Comparator, reactance ..... Nov. *142
Computers, electronic. William Shannon ..... Aug. *110
Contactors for control applications. W. D. Macgeorge ..... Apr. *186
Contour controller for machine tools. J. M. Morgan ..... Oct. *92
Control for machine tools, contouring. Feb. *178
Control of electric blanket, electronic. Feb. *186
Control and recording with floating grid. E. L. Deeter ..... Jan. *172
Controls rotating mandrel, fifty-foot light-beam ..... Apr. *164
Control, sensitive photoelectric .... Oct. *174
Converter, crystal mixer in f-m ... May *190
Converter, tubeless, for new f-m band. H. A. Audet ..... Oct. *140
Converter tubes, recent developments in. Harris & Dunn ..... Jan. *240
Converter, twelve-channel f-m. Young & Harris ..... Dec. *110
Cooking in slot machine, electronic.. Mar. *164
Cosmic ray measurements..... Dec. *214
Counter, high-speed ..... Nov. *190
Coupling, gas-tube, for d-c amplifiers. Iannone & Baller ..... Oct. *106
Crossroads electronics program. Fink & Engleman ..... Nov. *84
Crystal rectifiers. W. E. Stephens.. July *112

D

Decca navigation system for ships and planes ..... Sept. *174
Depth sounder for shallow water, echo. G. B. Shaw ..... Sept. *88
Detector, high-level. J. G. Rankin.. May *212
Diathermy, crystal-controlled. R. L. Norton ..... Oct. *113
Direction finder, static, reveals storm location ..... Feb. 212
Donutron ..... Nov. *200
Drills, tubes warn of dull..... Mar. 164
Dust meter, electric. Barnett & Free.. Dec. *116
Dynamic suppression of phonograph record noise. H. H. Scott..... Dec. *92
Dynamotors, maintenance testing of. H. M. Tremaine ..... June *158

E

Electroforming microwave components. Hassell & Jenks..... Mar. *134
Electrometer input circuits. H. A. Thomas ..... Dec. *130
Electronic heating conference..... Nov. 184
Electrophoresis ..... Sept. *196
Engineering advances in four years (I.R.E. meeting) ..... Mar. *92
Engines, pressure-time curves in electronic observation of W. F. Brown. Feb. *168
Exciter for structural testing, vibration. P. J. Holmes..... Dec. *96
Exciter-regulator for aircraft alternators. Hadley, Forsberg & Krauer..... July *120
Expander, surgeless volume. A. N. Butz Jr. ..... Sept. *140

F

Facsimile over 4,000-mc relay system. Oct. *146
Facsimile synchronizing methods. Daniel Schuman ..... Mar. *131
Facsimile to moving train via vhf.... July *168
Fault locator for power lines..... Dec. *198
Filters—effect of incidental dissipation. E. A. Guillemin..... Oct. *130
Fire and flame detector. P. B. Weisz. July *106
Fish fence controlled by electronic generator ..... Mar. *164
Flame radiation measuring instrument. E. M. Yard ..... Nov. *96
Flaw detector. R. B. De Lano.... Jan. *132
Flight trainer, electronic ..... Sept. *170
Flying, all-weather ..... Sept. *84
Flying with electronic equipment, automatic ..... May 186
Food sorting system, phototubes control ..... July *152
Frequency allocations, FCC..... June 15-82
Frequency modulation band, converter circuit for ..... Apr. *212
Frequency-modulation detector, single-stage. W. E. Bradley..... Oct. *88
Frequency-modulation in cabs, mobile twoway ..... Sept. *182
Frequency-modulation techniques .. May *208
Frequency-modulation transmitter for 88-108 mc. S. L. Sack..... Mar. *184
Frequency stabilization at 450 mc. P B. Myers ..... Apr. 214
Fuel consumption indicator. D. W. Moore, Jr..... Mar. *152
Fuze for artillery, proximity. Harner Selvidge ..... Feb. *104
Fuzes for electronic mines..... Oct. 162

G

Gage, electronic comparator. W. H. Hayman ..... July *134
Gage for tubes and pipes, electronic bore Feb. *190
Gage, radium-type vacuum. G. L. Mellen. Apr. *142
Galactic and solar noise..... Aug. 200
Gas-tube coupling for d-c amplifiers. Iannone & Baller ..... Oct. *106
Gate circuit for chronographs. L. B. Tooley ..... May *144
Generator, rectangular-pulse. McCombs & Walz ..... Mar. *222
Generator, thermoelectric. J. M. Lee. May *196
Geomagnetism and the aurora. C. W. Gartlein ..... Jan. 242
German industrial techniques..... July 200 Dec. 216
Germanium crystal diode E. C. Cornelius pt. 1 Jan. *252 pt. 2 Feb. 118

* Illustrated

H

Handie-talkie, twelve-tube f-m. J. M. Lee ..... Mar. *194
Heat, detection of ..... June 224
Heating, automatic frequency control for r-f. S. I. Rambo ..... Apr. *120
Heating conference, electronic ..... Nov. 184
Heating developments, high-frequency ..... May *170
Heating generators, radiation from r-f. A. G. Swan ..... May *162
Heating in bakery industry, r-f ..... Apr. *166
Heating in the furniture industry, electronic. E. S. Winlund ..... May *108
Heating seals giant balls, dielectric ..... July *158
Heating, tool brazing with induction ..... July *152
High-vacuum systems, gas locator ..... June *158
Horseshoes made by electronic smithy. ..... Oct. 170
Humidity and temperature recorder-controller Hauck, Sturm & Colt ..... Sept. *96

I

Impedance-admittance conversion chart. R. C. Paine ..... Jan. *162
Impedance Nomograph. G. J. Wheeler. ..... Sept. *186
Impedance of balanced lines, characteristic. P. J. Sutro ..... July *150
Index of Electronics, ten year ..... June 15-161
Inductance and capacitance, measuring mutual. A. W. Simon ..... Aug. *142
Induction heaters, duplex operation of. W. C. Budd ..... Nov. *93
Infrared detector, radioactive ..... Oct. *142
Infrared equipment, night vision with electronic ..... June *192
Infrared image tube. Morton & Flory. ..... Sept. *112
Infrared radiation, source of ..... Dec. 228
Infrasonic switching. Angelo Montani. ..... Mar. *214
Input circuits, electrometer. H. A. Thomas ..... Dec. *130
Inspection in post office, electronic package ..... Jan. *166
Institute of Radio Engineers 1946 Winter Technical Meeting ..... Mar. *92
Instrumentation: state of the art ..... Nov. 198
Intermediate-frequency coils, production testing of ..... Sept. *178
Intermediate-frequency transformers. R. T. Thompson ..... Sept. *142
Intermodulation testing. J. H. Hilliard. ..... July *123
Ionosphere studies ..... June 234
Ionosphere measuring equipment. P. G. Sulzer ..... July *137

L

Lamp, modulated arc ..... Nov. *150
Lighting control, photoelectric street. C. E. Marshall ..... Sept. *134
Limiter and squelch circuit combined ..... Dec. *222
Limiters, noise and output. Emerick Toth, pt. 1, Nov. *114; pt. 2 ..... Dec. *120
Linear sweep circuits. R. P. Owen ..... Dec. *136
Linear sweep generator analysis. E. L. Langbergh ..... Nov. *194
Liner, electronics on world's largest ..... Dec. *84
Load lamp for microwave power measurements. J. E. Beggs ..... June *204
Logarithmic photometer. M. H. Sweet. ..... Nov. *105
London letter. J. H. Jupe ..... Oct. 150
Loran transmitting stations ..... Mar. *109
Loudspeaker, design of compact twohorn. P. W. Klipson ..... Feb. *156

M

Machine tool contour controller. J. M. Morgan ..... Oct. *92
Magnetic testing of metals. Cavanagh, Mann & Cavanagh ..... Aug. *114
Magnetizer for plant shops, capacitor discharge. W. L. Porta ..... June *168
Magnetrons, cavity ..... Jan. *126
Magnetrons, Japanese. Marvin Hobbs ..... May *114
Magnetron, rising sun ..... Aug. *203
Magnetostriction pickup, torsional. S. R. Rich ..... June *107
Materials tester ..... Dec. *206
Medicine, electronics in ..... Aug. 166
Metals, automatic analysis of elements in ..... Feb. *194
Metal detector for conveyor belts ..... May *160
Metascope, an infrared detector ..... Oct. *142
Meteorology ..... Aug. 198
Meter, components of ultra high frequency field. Edward Karplus ..... Nov. *124
Meters, production testing of panel. Roscoe Ammon ..... Feb. *170
Micrometer, capacitance. Dayton & Foley ..... Sept. *106
Microphone, electronic. Jerome Rothstein ..... Mar. *230
Micrometer for thin materials ..... Oct. *190
Microwave, power measurements, load lamp for. J. E. Beggs ..... June *204
Microwaves, thyratron pulser tube for industrial ..... May *170
Mine detector. Doll, Lebourg & Miller ..... Jan. *105
Missiles, radio control systems for guided. Ackerman & Rappaport ..... Dec. *86
Mixer frequency charts. R. S. Badessa. ..... Aug. *138
Modulator, cascade phase shift. M. Marks ..... Dec. *104
Modulation in new system, grid and plate ..... May *192
Modulation of electron flow, mechanical. ..... July *178
Moisture testing of granular material. J. H. Jupe ..... May *180
Motor control, unsoldered connections for ..... June *156
Motors, synchronizing electric ..... Jan. *166
Movie of a movie ..... Dec. *234
Multicarrier communication ..... Sept. *192
Multivibrator circuits. N. W. Mather. ..... Oct. *136

N

Navigation system for ships and planes, Decca ..... Sept. *174
Nerve stimulator. W. I. Weiss ..... Feb. *155
Networks, wideband phase shift. R. B. Dome ..... Dec. *112
Noise and output limiters. Emerick Toth. pt. 1, Nov. *114; pt. 2, Dec. *120
Nonlinear circuit element applications. H. E. Kallmann ..... Aug. *130

O

Oscillator, bimodal. Samuel Lubkin ..... Feb. *242
Oscillator circuits, cavity. A. M. Gurewitsch ..... Feb. *135
Oscillator, thermistor-regulated low-frequency. Lawrence Fleming ..... Oct. *97
Oscillator, two-terminal. M. G. Crosby ..... May *136
Oscillograph, high speed. N. Rohats ..... Apr. *135
Oscilloscope for television stations, test. Brolly & Brock ..... Nov. *120

P

Panoramic receivers, alarm systems for. W. A. Anderson ..... July *92
Patents ..... May 228, Aug. 206
Patent puzzle. Col. D. K. Lippincott ..... May 92
Pen, electrodynamic direct-inking. H. B. Shaper ..... Mar. *148
Pentagrids—new uses. A. H. Taylor ..... Dec. *142
Phase-shifter nomograph. R. E. Lafferty. ..... May *158
Phasitron frequency modulation transmitter. Bailey & Thomas ..... Oct. *108
Phonograph, high-fidelity ..... Dec. *178
Phonograph record noise, dynamic suppression of. H. H. Scott ..... Dec. *92
Photometer, logarithmic. M. H. Sweet. ..... Nov. *105
Photosensitive cells, cooling. E. F. Coleman ..... June *220
Phototube sees x-rays ..... Nov. *180
Pickup, carbon phonograph. Kaufman & Kaufman ..... Sept. *162
Pickup, improved modulated-oscillator. Henry Kalmus ..... July *182
Pickup with low mechanical impedance. H. P. Kalmus ..... Jan. *140
Pilot guides ships, auxiliary. J. H. Jupe. ..... Aug. 154
Power supplies, multi-voltage regulated. J. R. Mentzer ..... Sept. *132
Power supplies, rotary converter for portable ..... Aug. *142
Printing, photoelectric controls for color. Robins & Varden ..... June *110
Production control with 2,000,000-volt x-rays. David Goodman ..... Feb. *147
Production research ..... Sept. *186
Proximity fuze for artillery. Harner Selvidge ..... Feb. *104
Proximity fuze, radio. Herbert Trotter, Jr. ..... Jan. 226
Proximity fuze tubes. M. A. Acheson. ..... Jan. 228
Pulse characteristics, measuring. Allan Easton ..... Feb. *150
Pulse communication. C. W. Hansell. ..... June *226
Pulse-modulated radio relay equipment. J. J. Kelleher ..... May *124
Pulse modulating system. W. R. Greer. ..... Sept. *126
Pulse time modulation circuits ..... Nov. *140
Pulse transmission in amplifiers. A. E. Newlon ..... Oct. *116
Punch press protector. John Isaacs ..... Dec. *101

Q

Queen Elizabeth—electronics on world's largest liner ..... Dec. *84

R

Radar countermeasures ..... Jan. *92
Radar echoes from the moon. Jack Mofenson ..... Apr. *92
Radar for blind bombing. Holdam, McGrath & Cole, pt. 1, May *136; pt. 2, ... June *142
Radar for carrier-based planes. C. B. Barnes ..... Oct. *100
Radar for weather man ..... June 210
Radar, future of. L. A. Du Bridge ..... Jan. 254
Radar-guided bomb ..... Dec. *186
Radar increases safety of night boat. ..... Apr. *164
Radar, the MPG-1. H. A. Strauss & others ..... Jan. *110; Mar. *140
Radar, microwave. D. G. Fink ..... Jan. 236
Radar on 50 centimeters. Zahl & Marchetti, Jan. *98 ..... Feb. *98
Radar and radio direction-finding sets for weather forecasting. H. B. Brooks. ..... Oct. *84
Radar, rotary wave. Walter van B. Roberts ..... July *130
Radar, SCR-584 ..... Feb. *110
Radar target, artificial ..... Feb. *214
Radarange for cooking ..... Nov. *178
Radio control systems for guided missiles. Ackerman & Rappaport ..... Dec. *86
Radio design data presented in Chicago. ..... Apr. *216
Radio remote control, continuously variable. D. W. Moore, Jr. ..... Nov. *110
Radio, two-way, for power line crews. ..... Nov. *123
Radiolocation, evolution of ..... Oct. 214
Railroad radio . . . from FCC to ICC. Jeremiah Courtney ..... June *92
Receiver design, modern home. Z. Benin ..... Aug. *94
Receiver for comparison tests, f-m and a-m. W. F. Frankart ..... July *168
Receiver measurements, vhf. Gordon & George ..... June *214
Receiver output circuit, midget. W. R. Koch ..... June *232
Record-selection system, remote. F. M. Berry ..... June *104
Recording CAA traffic control instructions. K. M. MacIlvain ..... May *116
Recording on magnetic wire, high quality sound. L. C. Holmes ..... Jan. 236
Recording, progress in magnetic ..... Aug. *140
Recording the war trials in four languages ..... May *202
Rectifier, capacitor charging. H. J. Bichsel ..... Jan. *123
Rectifiers, grid-controlled, for r-f heating. Bruce Boyd ..... Oct. *125
Rectifiers, reduced harmonic voltage across. Mendel Osmos ..... Feb. *248
Rectifier wave-form control. G. B. Hagen ..... Sept. *200
Relativity ..... Oct. 220
Resin adhesives for r-f heating ..... Dec. *202
Resnatron. W. W. Salisbury ..... Feb. *92
Resonant circuit ..... Sept. *190
Return trace, speeding up the. A. H. Taylor ..... Nov. *176
Rubber preheater. Mittelmann & Bosomworth ..... Mar. *128

S

Seals, r-f soldering of metal-to-glass. R. A. Ammon ..... Mar. *120
Servo motor. D. W. Moore, Jr. ..... Nov. *110
Shutter-testers. R. F. Redemske ..... Feb. *128
Sight, electronic night ..... June *95
Sight for solar telescope, photoelectric. W. O. Roberts ..... June *100
Signal generator design, frequency-modulation. Hill & Crosby ..... Nov. *96
Signal-to-noise ratios, theoretical. J. E. Smith ..... June *150
Skiatron ..... Oct. 216
Sniperscope and Snooperscope ..... June *95
Soap dispenser for dish-washing ..... Oct. 182
Society of Motion Picture Engineers conference ..... July 188
Soldering of metal-to-glass seals. R. A. Ammon ..... Mar. *120
Sonar, echo ranging. R. J. Evans ..... Aug. *88
Sonar for submarines. Lanier & Sawyer. ..... Apr. *99
Sonar uses. Doppler effect ..... Oct. 142
Sonobuoy ..... Apr. *154
Sound effects circuit, electronic. Howard Syzling ..... Jan. *214
Sound-pressure measurement standard. Frank Massa ..... May *218
Sound, problem in outdoor. Ellis & Gilmore ..... Dec. *126
Sound systems, high-power military. ..... Feb. *216
Speaker cabinet. C. A. Volf ..... Mar. *206
Spectrograph exposure control. J. R. Cosby ..... Apr. *123
Spectrum chart following page 80 ..... June 15
Speech patterns transmit intelligence, visible ..... Jan. *200
Speedometer for aircraft, radio-beam. ..... Oct. 170
Squelch and limiter circuit combined ..... Dec. *222
Station techniques, new ..... Nov. 168
Stenotrone ..... Nov. *204
Storm detector for spherics ..... Apr. *224
Subminiature tube, circuits for ..... May *154
Superheterodyne, oscillatorless. R. W. Woods ..... Feb. *224

* Illustrated

Superregenerative detector selectivity. Allan Easton ..... Mar. *154
Supersonic flaw detector ..... Dec. *198
Supersonic flaw detector. R. B. De Lano, Jr. ..... Jan. *132
Supersonic inspection of strip materials. Mar. *166
Switch, four-channel electronic. N. A. Moerman ..... Apr. *150
Switching, instantaneous program. Joseph Zelle ..... Feb. *142

T

Tank circuit for uhf, composite. P. L. Bargellini ..... Sept. *115
Telemetering system, radiosonde. Hauck, Cosby & Dember ..... May *120
Teleran proposal. P. J. Herbst & others. Feb. *124
Television, all-electronic color ..... Dec. *140
Television, industrial standardization work in. D. B. Smith ..... Jan. 244
Television, color, on ultra high frequencies ..... Apr. *109
Television console ..... Mar. *200
Television, projection ..... Nov. *212
Television stands, where color. D. G. Fink ..... May 104
Television sweep, current oscillator for. G. C. Sziklai ..... Sept. *120
Temperature and humidity recorder-controller. Hauck, Sturm & Colt ..... Sept. *96
Tester, materials ..... Dec. *206
Testing heat exchanger tubing ..... Aug. *174
Thermal problems, electrical solution of. F. C. Willey ..... Aug. *190
Thyratron circuits, multiple. Irving Sager ..... Dec. *158
Thyratrons, hydrogen. Harold Heins. July *96
Thyratron life extension ..... Nov. *210
Timer for inductive load ..... Oct. *170
Timer, tube-seasoning ..... Feb. *145
Timing up to thirty seconds, variable. D. G. Haines ..... July *154
Tone generator, photoelectric. L. E. Greenlee ..... Sept. *93
Tracking formulas, superhet. Joseph Marshall ..... Oct. *202
Tracking permeability-tuned circuits. A. W. Simon ..... Sept. *138
Traffic control with intercoms, plant truck ..... July *168
Train communication system, 2,660-mc. E. A. Dahl ..... Jan. *118
Train position indicator. E. A. Dahl. Oct. *122
Transceiver, 2,700-mc ..... Sept. *104
Transient delay line. J. M. Lester ..... Apr. *147
Transmission, 2-mc sky-wave. J. A. Pierce ..... May *146
Transmitter, phasitron frequency modulation. Bailey & Thomas ..... Oct. *108
Tube construction, lathe for ..... June *156
Tube for frequency modulation ..... Feb. *204
Tube design ..... June *214
Tubes, gaseous discharge, and applications. R. C. Hillard ..... Mar. *122
Tuned circuits, frequency stability of. G. V. Eltgroth ..... Feb. *118
Tuning for 44 to 216 mc, continuous. May 204

U

Ultra high frequency field meter components. Edward Karplus ..... Nov. *124
Ultra high frequency measurement ..... Nov. *216
Ultra high frequency wave propagation. Aug. 200
Ultrasonic generator. Smith & Stumpf. Apr. *116
Ultrasonic trainer circuits. F. L. Larsen ..... June *126

V

Vacuum-leak hunting, audio aid for. Victor Wouk ..... Feb. *138
Vibration exciter for structural testing. P. J. Holmes ..... Dec. *96
Voltage regulator, electronic a-c. L. D. Harris ..... Jan. *150
Voltmeter, high resistance d-c. D. L. Waidelich ..... Mar. *158
Voltmeter, inverse vacuum-tube. S. H. Dike ..... Aug. *140
Voltmeters, pulse response of diode. Allan Easton ..... Jan. *146
Vulcanizing on commercial basis, electronic ..... Jan. *164

W

Wattmeter, air-flow ultra high frequency. Wilchinsky & Kyser ..... Oct. *128
Wattmeter, microwave ..... Nov. *164
Waveguides, engineering approach to. Theodore Moreno ..... May *99
Waveguides, feasibility of dielectric. Oct. 222
Waveguides, flexible. Anderson & Winchell ..... Aug. *104
Waveguides, minimum attenuation in. E. N. Phillips ..... Jan. *137
Waveguide transmission systems. Theodore Moreno ..... June *136
Weather forecasting. H. B. Brooks ..... Oct. *84
Welding, current-force recording in resistance. J. M. Popp ..... Aug. *166

X

X-ray industrial building ..... Nov. *192
X-rays, production control with 2,000,000 volt. David Goodman ..... Feb. *147
X-rays seen by phototube ..... Nov. *180
X-rays, source of high-intensity ..... Mar. 228

AUTHORS' INDEX

ACHESON, MARCUS A. Proximity fuze tubes ..... Jan. 228
Ackerman, Capt. Sam L. & George Rappaport. Radio control systems for guided missiles ..... Dec. *86
Adler, Robert. Reentrant pentode a-f amplifier ..... June *123
Agnew, N. F. Sorting alloys ..... Sept. *124
Ammon, Roscoe. Production testing of panel meters ..... Feb. *170
Ammon, R. A. R-f soldering of metal-to-glass seals ..... Mar. *120
Anderson, Alton R. & A. M. Winchell. Flexible waveguides ..... Aug. *104
Anderson, W. A. Alarm system for panoramic receivers ..... July *92
Audet, H. A. Tubeless converter for new f-m band ..... Oct. *140

BABCOCK, HORACE W. Electronic code translator ..... June *120
Badessa, R. S. Mixer frequency charts. Aug. *138
Bailey, F. M. & H. P. Thomas. Phasitron frequency modulation transmitter ..... Oct. *108
Baller, Howard & Fulvio Iannone. Gas-tube coupling for d-c amplifiers. Oct. *106
Bargellini, Pier L. Composite tank circuit for uhf ..... Sept. *115
Barnes, C. B. Radar for carrier-based planes ..... Oct. *100
Barnett, Guy F. & A. L. Free. Electric dust meter ..... Dec. *116
Barton, Don. Beat-frequency interference chart ..... Apr. *162
Beggs, George E., Jr. Bridging amplifier for f-m monitoring ..... Jan. *153
Beggs, J. E. Load lamp for microwave power measurements ..... June *204
Benin, Z. Modern home receiver design ..... Aug. *94
Berry, Fred M. Remote record-selection system ..... June *104
Best, John H. Vibration and shock testing of mobile equipment ..... Apr. *126
Bichsel, Harry J. Capacitor charging rectifier ..... Jan. *123
Blow, T. C. Mutual inductance of concentric coils ..... Nov. *138
Bosomworth, G. P. & Eugene Mittelmann. Electronic rubber preheater ..... Mar. *128
Boyd, Bruce. Grid-controlled rectifiers for r-f heating ..... Oct. *125
Bradley, William E. Single-stage frequency modulation detector ..... Oct. *88
Brock, W. R. & A. H. Brolly. Test oscilloscope for television stations. Nov. *120
Brolly, A. H. & W. R. Brock. Test oscilloscope for television stations. Nov. *120
Brooks, Herbert B. Weather forecasting. ..... Oct. *84
Brown, W. F. Pressure-time curves in electronic observation of engines. Feb. *168
Brunetti, Cledo & A. S. Khouri. Printed electronic circuits ..... Apr. *104
Bullock, Theodore H. Double-beam c-r tube in biological research ..... July *103
Butz, A. Nelson, Jr. Surgeless volume expander ..... Sept. *140

CAVANAGH, P. E., E. R. Mann & R. T. Cavanagh. Magnetic testing of metals ..... Aug. *114
Cole, A. D., J. V. Holdam & S. McGrath. Radar for blind bombing, pt. 1, May *138; pt. 2 ..... June *142
Cole, Larry S. Measuring and monitoring broadcast frequencies ..... July *110
Coleman, Eugene F. Cooling photosensitive cells ..... June *220
Colt, R. B., V. D. Hauck & R. E. Sturm. Recorder-controller for temperature and humidity ..... Sept. *96
Cornelius, Edward C. Germanium crystal diode, Jan. *252 ..... Feb. *118
Cosby, J. R. Spectrograph exposure control ..... Apr. *123
Cosby, J. R., V. D. Hauck & A. B. Dember. Radiosonde telemetering systems ..... May *120
Courtney, Jeremiah. Railroad radio . . . from FCC to ICC ..... June *92
Cox, C. R. Design data for beaded coaxial lines ..... May *130
Remote indicating antenna ammeter. Jan. *210
Cranberg, Lawrence. Sensory aid for the blind ..... Mar. *116
Crosby, Murray C. Two-terminal oscillator ..... May *136
Crosby, Murray G. & D. M. Hill. Design of frequency-modulation signal-generator ..... Nov. *96

DAHL, ERNEST A. Train position indicator ..... Oct. *122
2,660-mc train communication system ..... Jan. *118
Davis, R. J. & others. The MPG-1 radar. Jan. *110
Dayton, R. W. & G. M. Foley. Capacitive micrometer ..... Sept. *106
Deeter, E. L. Control and recording with floating grid ..... Jan. *172
De Lano, Ralph B., Jr. Supersonic flaw detector ..... Jan. *132
Dember, A. B., V. D. Hauck & J. R. Cosby. Radiosonde telemetering systems ..... May *120
Dike, Sheldon H. Inverse vacuum-tube voltmeter ..... Aug. *140
Doll, H. G., M. Lebourg & G. K. Miller. Vehicular-mounted mine detector ..... Jan. *105
Dome, R. B. Wideband phase shift networks ..... Dec. *112
DuBridge, L. A. Future of radar ..... Jan. 254
Dunn, R. F. & W. A. Harris. Recent developments in converter tubes. Jan. *240

EASTON, ALLAN. Measuring pulse characteristics ..... Feb. *150
Pulse response of diode voltmeters. Jan. *146
Superregenerative detector selectivity ..... Mar. *154
Ellis, A. B. & J. P. Gilmore. A problem in outdoor sound ..... Dec. *126
Engleman, Capt. C. L. & D. G. Fink. First published details of Crossroads electronics program ..... Nov. *84
Evans, Richard J. Echo ranging sonar. Aug. *88
Ewing, Douglas & others. The Teleran proposal ..... Feb. *124

FINK, DONALD G. Microwave radar. Jan. 236
Where color television stands ..... May 104
Fink, D. G. & Capt. C. L. Engleman. First published details of Crossroads electronics program ..... Nov. *84
Finzi, Dr. L. A. An electronic bypass for measuring purposes ..... Feb. *196
Fleming, Lawrence. Thermistor-regulated low-frequency oscillator. Oct. *97
Flory, L. E. & G. A. Morton. Infrared image tube ..... Sept. *112
Flory, L. E. & V. K. Zworykin. Reading aid for the blind ..... Aug. *84
Foley, G. M. & R. W. Dayton. Capacitive micrometer ..... Sept. *106
Forsberg, Arthur W., P. T. Hadley & O. Krauer. Exciter-regulator for aircraft alternators ..... July *120
Frankart, William F. Frequency-modulation and amplitude-modulation receiver for comparison tests. July *168
Free, A. L. & G. F. Barnett. Electric dust meter ..... Dec. *116
Fundingsland, O. T. & G. J. Wheeler. Constant current circuits ..... Nov. *130

GARTLEIN, C. W. The aurora and geomagnetism ..... Jan. 242
George, Louis & Howard Gordon. Vhf receiver measurements ..... June *214
Gillespie, Charles N. Compensating amplifier ..... Mar. *232
Gilmore, James P. & A. B. Ellis. A problem in outdoor sound ..... Dec. *126
Goldman, Albert. Pulse-type radio altimeter ..... June *116
Goodell, John D. & B. M. H. Michel. Auditory perception ..... July *142
Goodman, David. Production control with 2,000,000-volt x-rays ..... Feb. *146
Gordon, Howard & Louis George. Vhf receiver measurements ..... June *214
Greenlee, Lyman E. Photoelectric tone generator ..... Sept. *93
Greer, William R. Pulse modulating system ..... Sept. *126
Gross, Ervin E., Jr. Coaxial butterfly circuits ..... Apr. *156
Coaxial modification of the butterfly circuit ..... Jan. *222
Guillemin, E. A. The effect of incidental dissipation in filters ..... Oct. *130
Gurewitsch, A. M. Cavity oscillator circuits ..... Feb. *135

HADLEY, PAUL T., A. W. Forsberg & O. Krauer. Exciter-regulator for aircraft alternators ..... July *120
Hagen, Gerhard B. Rectifier wave-form control ..... Sept. *200
Haines, Donald G. Variable timing up to thirty seconds ..... July *154
Hansell, Clarence W. Pulse communication ..... June *226
Harries, J. H. Owen. Apertures in cavities ..... Dec. *132
Harris, L. Dale. Electric a-c voltage regulator ..... Jan. *150
Harris, W. A. & R. F. Dunn. Recent developments in converter tubes. Jan. *240
Harris, W. A. & J. E. Young. Twelve-channel f-m converter ..... Dec. *110
Hasler, Arthur D. & L. V. Whitney. Photoelectric fish counter ..... Mar. *178

* Illustrated

Hassell, F. & F. Jenks. Electroforming microwave components ....Mar. *134
Hauck, V. D., J. R. Cosby & A. B. Dember. Radiosonde telemetering systems .....May *120
Hauck, V. D., R. E. Sturm & R. B. Colt. Recorder-controller for temperature and humidity.....Sept. *96
Hayman, W. H. Electronic comparator gage .....July *134
Heins, Harold. Hydrogen thyratrons. July *96
Herbst, P. J. & Others. The Teleran proposal .....Feb. *124
Hill, Donald M. & M. G. Crosby. Design of frequency-modulation signal generator .....Nov. *96
Hilliard, John A. Intermodulation testing .....July *123
Hilliard, R. C. Gaseous discharge tubes and applications .....Mar. *122
Hills, E. G. VHF antenna for trains. Nov. *134
Hobbs, Marvin. Japanese magnetrons. May *114
Holdam, J. V., S. McGrath & A. D. Cole. Radar for blind bombing, pt. 1, May *138; pt. 2.....June *142
Holmes, Lynn C. High quality sound recording on magnetic wire..Jan. 236
Holmes, Paul J. Vibration exciter for structural testing .....Dec. *96
Howard, William A. Portable video pickup equipment .....Aug. *124

IANNONE, FULVIO & Howard Baller. Gas-tube coupling for d-c amplifiers .....Oct. *106
Isaacs, John. Punch press protector.Dec. *101

JENKS, F. & F. HASSELL. Electroforming microwave components. Mar. *134
Jolter, Norman J. Measurement of ocean waves generated by atomic bombs .....May *94
Jones, Loren F. & others. The Teleran proposal .....Feb. *124
Jupe, John H. Auxiliary pilot guides ships .....Aug. 154
London letter .....Oct. 150
Rapid moisture testing of granular material .....May *180

KALLMANN, Heinz E. Nonlinear circuit element applications...Aug. *130
Kalmus, Henry. Improved modulated-oscillator pickup .....July *182
Kalmus, Henry P. Pickup with low mechanical impedance .....Jan. *140
Karplus, Edward. Components of ultra high frequency field meter..Nov. *124
Kaufman, Alvin B. & E. N. Kaufman. Carbon phonograph pickup.Sept. *162
Kaufman, Edwin N. & A. B. Kaufman. Carbon phonograph pickup.Sept. *162
Kelleher, John J. Pulse-modulated radio relay equipment .....May *124
Khouri, A. S. & Cledo Brunetti. Printed electronic circuits .....Apr. *104
Klipsch, Paul W. Design of compact two-horn loudspeaker .....Feb. *156
Knowles, Hugh S. War influence on acoustic trends .....Jan. *246
Koch, Winfield R. Midget receiver output circuit .....June *232
Kramer, B. & Fred Stolte. Measurement of velocity of propagation in cable .....July *128
Krauer, O., P. T. Hadley and A. W. Forsberg. Exciter-regulator for aircraft alternators .....July *120
Kulansky, J. K. Selective calling system .....June *96
Kyser, Russell H. & Z. W. Wilchinsky. Air-flow ultra high frequency wattmeter .....Oct. *128

LAFFERTY, RAYMOND E. Phase-shifter nomograph .....May *158
Laing, E. M. Sensitive photoelectric control .....Oct. *174
Langberg, Eugene L. Analysis of linear sweep generator .....Nov. *194
Lanier, R. S. & C. R. Sawyer. Sonar for submarines .....Apr. *99
Larsen, Finn J. Ultrasonic trainer circuits .....June *126
Lebourg, M., H. G. Doll & G. K. Miller. Vehicular-mounted mine detector .....Jan. *105
Lee, J. M. Thermoelectric generator for portable equipment .....May *196
Twelve-tube f-m handie-talkie..Mar. *194
Lester, John M. Transient delay line. Apr. *147
Lippincott, Col. Donald K. Patent puzzle .....May 92
Lubkin, Samuel. Bimodal oscillator. Feb. *242

MACGEORGE, W. D. Electronic contactors for control applications. Apr. *186
MacIlvain, K. M. Recording CAA traffic control instructions .....May *116
Mann, E. R., P. E. Cavanagh & R. T. Cavanagh. Magnetic testing of metals .....Aug. *114
Marchetti, Maj. John W. & Lt. Col. H. A. Zahl. Radar on 50 centimeters. Jan. *98 .....Feb. *98
Marks, M. Cascade phase shift modulator .....Dec. *104
Marshall, Charles E. Photoelectric street lighting control .....Sept. *134
Marshall, Joseph. Superhet tracking formulas .....Oct. *202
Massa, Frank. Sound-pressure measurement standard .....May *218
Mater, Norman W. Multivibrator circuits .....Oct. *136
McCombs, Rollin & F. C. Walz. Rectangular-pulse generator .....Mar. *222
McGrath, S., J. V. Holdam & A. D. Cole. Radar for blind bombing, pt. 1, May *138; pt. 2.....June *142
McManus, Lindsay. Two-station antenna system .....Nov. *154
Mellen, Glenn L. Radium-type vacuum gage .....Apr. *142
Mentzer, J. R. Multi-voltage regulated power supplies .....Sept. *132
Miller, G. K., M. Lebourg & H. G. Doll. Vehicular-mounted mine detector .....Jan. *105
Mittelmann, Eugene & G. P. Bosomworth. Electronic rubber preheater .....Mar. *128
Moerman, N. A. Four-channel electronic switch .....Apr. *150
Mofenson, Jack. Radar echoes from the moon .....Apr. *92
Montani, Angelo. Infrasonic switching. Mar. *214
Moore, David Wm., Jr. Continuously variable radio remote control. Nov. *110
Fuel consumption indicator....Mar. *152
Moreno, Theodore. Engineering approach to wave guides.....May *99
Waveguide transmission systems. June *136
Morgan, J. M. Machine-tool contour controller .....Oct. *92
Moritz, Clement. Transient video analyzer .....June *130
Morton, G. A. & L. E. Flory. Infrared image tube .....Sept. *112
Myers, Peter B. Frequency stabilization at 450 mc .....Apr. 214

NEWLON, ARTHUR E. Pulse transmission in amplifiers.....Oct. *116
Norton, R. L. Crystal-controlled diathermy .....Oct. *113

OSNOS, MENDEL. Reduced harmonic voltage across rectifiers....Feb. *248
Owen, Robert P. Linear sweep circuits Dec. *136

PAINE, ROBERT C. Impedance-admittance conversion chart.....Jan. *162
Paul, I. & T. J. Wang. Betatron pulsing system .....Jan. *156
Phillips, Edwin N. Minimum attenuation in waveguides .....Jan. *137
Pierce, J. A. 2-mc sky-wave transmission .....May *146
Popp, J. M. Current-force recording in resistance welding .....Aug. *166
Porta, William L. Capacitor discharge magnetizer for plant shops.June *168

RAMBO, S. IVAN. Automatic frequency control for r-f heating. Apr. *120
Rankin, J. C. High-level detector..May *212
Rappaport, George & Capt. S. L. Ackerman. Radio control systems for guided missiles .....Dec. *86
Redemake, R. F. Electronic shutter-testers .....Feb. *128
Reisman, S. J. & others. The MPG-1 radar.....Jan. *100; Mar. *140
Rich, Stanley R. Torsional magnetostriction pickup .....June *107
Roberts, Walter Orr. Photoelectric sight for solar telescope.....June *100
Roberts, Walter van B. Rotary wave radar .....July *130
Robins, J. & L. E. Varden. Photoelectric controls for color printing..June *110
Rogers, Gordon F. Isolation amplifiers for aircraft .....Aug. *122
Rohats, N. High speed oscillograph. Apr. *135
Rothstein, Jerome. Electronic microphone .....Mar. *230
Rudd, W. C. Duplex operation of induction heaters .....Nov. *93
Rueger, L. J. & others. MPG-1 radar. Mar. *140
The MPG-1 radar.....Jan. *110

SACK, SAMUEL L. Design of f-m transmitter for 88-108 mc..Mar. *184
Sagar, Irving. Multiple thyratron circuits .....Dec. *158
Salisbury, Winfield W. The resnatron. Feb. *92
Schulman, Daniel. Facsimile synchronizing methods .....Mar. *131
Scott, H. H. Dynamic suppression of phonograph record noise....Dec. *92
Selvidge, Harner. Proximity fuze for artillery .....Feb. *104
Shannon, William. Electronic computers. Aug. *110
Shaper, H. B. Electrodynamic direct-inking pen .....Mar. *148
Shaw, G. B. Echo depth sounder for shallow water .....Sept. *88
Shive, Scott L. Effectiveness of conduit as r-f shielding.....Feb. *160
Silverman, M. Streamlining c-r tube production .....July *164
Tube-seasoning timer .....Feb. *145
Simon, A. W. Measuring mutual inductance and capacitors.....Aug. *142
Tracking permeability-tuned circuits. Sept. *138
Wire length of universal coils..Mar. *162
Smith, David B. Industrial standardization work in television.....Jan. 244
Smith, J. Ernest. Theoretical signal-to-noise ratios .....June *150
Smith, Frederick W., Jr. & P. K. Stumpf. Ultrasonic generator .....Apr. *116
Spitzer, E. E. Grounded-grid power amplifiers .....Apr. *138
Straus, H. A. & others. The MPG-1 raradar.....Jan. *110; Mar. *140
Stephens, W. E. Crystal rectifiers..July *112
Stolte, Fred & B. Kramer. Measurement of velocity of propagation in cable .....July *128
Stumpf, Paul K. & F. W. Smith, Jr. Ultrasonic generator .....Apr. *116
Sturm, R. E., V. D. Hauck & R. B. Colt. Recorder-controller for temperature and humidity.....Sept. *96
Sulzer, P. G. Ionosphere measuring equipment .....July *137
Sutro, Peter J. Characteristic impedance of balanced lines.....July *150
Swan, Arthur G. Radiation from r-f heating generators .....May *162
Sweet, Monroe H. Logarithmic photometer .....Nov. *105
Syzling, Howard. Electronic sound effects circuit. .....Jan. *214
Sziklai, George C. Current oscillator for television sweep .....Sept. *128

TAYLOR, A. H. New uses for pentagrids .....Dec. *142
Speeding up the return trace...Nov. *176
Taylor, J. H. & others. The MPG-1 radar .....Jan. *110, Mar. *140
Thomas, Harold A. Electrometer input circuits .....Dec. *130
Thomas, H. P. & F. M. Bailey. Phasitron frequency modulation transmitter .....Oct. *108
Thompson, Robert T. Two-frequency intermediate-frequency transformers .....Sept. *142
Tooley, L. B. Gate circuit for chronographs .....May *144
Toth, Emerick. Noise and output limiters, pt. 1, Nov. *114; pt. 2.Dec. *120
Travis, Earle. Cathode-coupled isolating amplifier .....Jan. *202
Direct-coupled r-f amplifier.....Dec. *158
Tremaine, H. M. Maintenance testing of dynamotors .....June *158
Trotter, Herbert, Jr. Radio proximity fuze .....Jan. 226

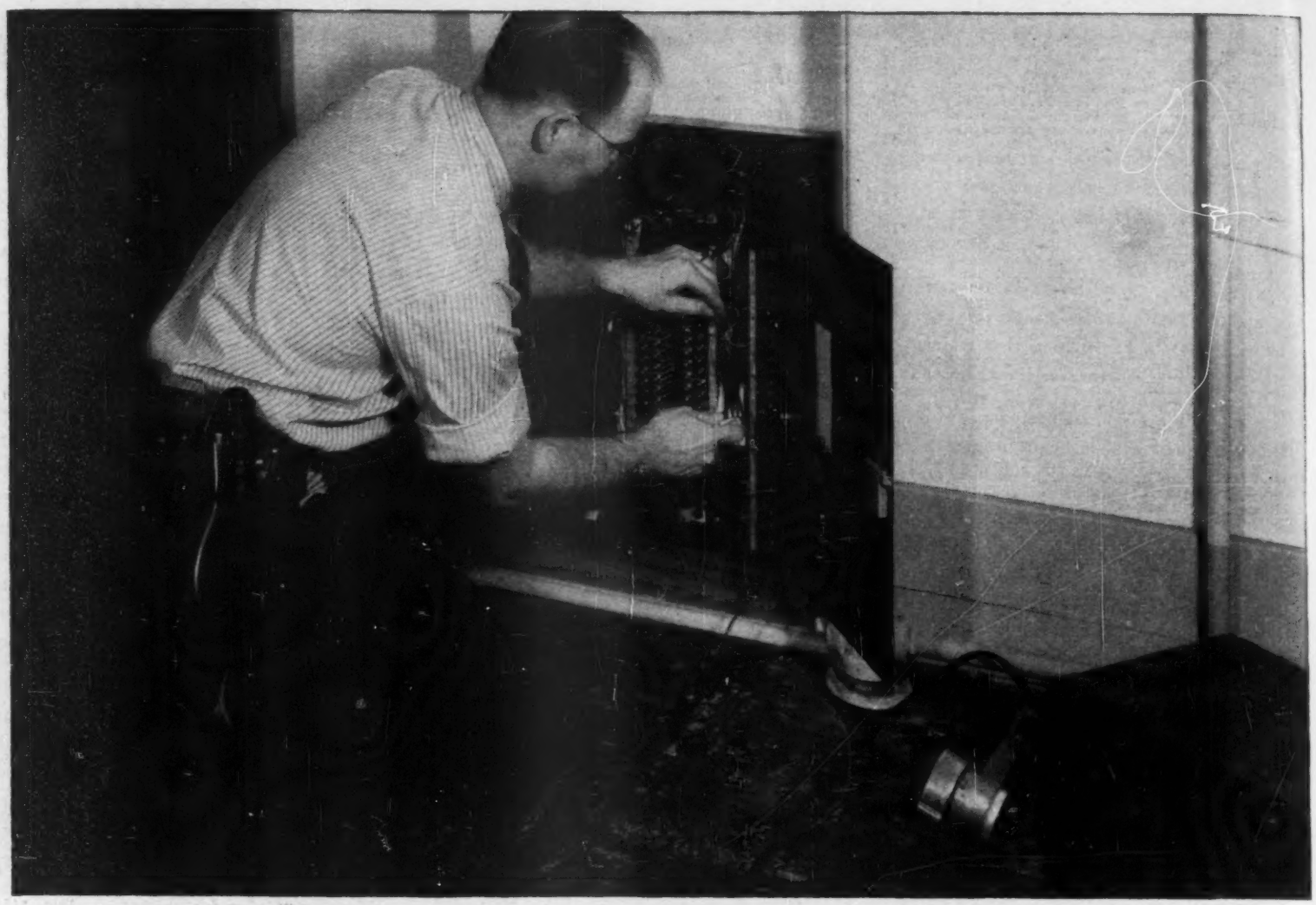
VAN JEPMOND, HOWARD A. Telephone amplifier .....Mar. *139
Varden, L. E. & J. Robins. Photoelectric controls for color printing..June *110
Vladimir, L. O. Low impedance loop antenna for broadcast receivers. Sept. *100
Volf, Christian A. Massive speaker cabinet .....Mar. *206

WAIDELICH, D. L. High-resistance d-c voltmeter .....Mar. *158
Walz, Frank C. & R. K. McCombs. Rectangular-pulse generator. Mar. *222
Wang, T. J. & I. Paul. Betatron pulsing system .....Jan. *156
Weiss, Walter I. Nerve stimulator..Feb. *155
Weisz, Paul B. Electronic fire and flame detector .....July *106
Wert, C. A. & others. The MPG-1 radar. Jan. *110; Mar. *140
Wheeler, G. J. & O. T. Fundingsland. Constant current circuits...Nov. *130
Wheeler, Gershon J. Impedance nomograph .....Sept. *186
Whitney, Lester V. & A. D. Hasler Photoelectric fish counter.....Mar. *178
Wilchinsky, Zigmond W. & R. H. Kyser. Air-flow ultra high frequency watt-meter .....Oct. *128
Willey, Frank G. Electrical solution of thermal problems .....Aug. *190
Winchell, Alfred M. & A. R. Anderson. Flexible waveguides .....Aug. *104
Winlund, E. S. Electronic heating in the furniture industry .....May *108
Wolff, Irving & others. The Teleran proposal .....Feb. *124
Woods, Robert W. Oscillatorless superheterodyne .....Feb. *224
Wouk, Victor. Audio aid for vacuum-leak hunting .....Feb. *138

YARD, EDWARD M. Flame radiation measuring instrument .....Nov. *96
Young, J. E. & W. A. Harris. Twelve-channel f-m converter.....Dec. *110
Yu, I. P. Cathode follower coupling in d-c amplifiers .....Aug. *99

ZAHL, LT. COL. HAROLD A. & Maj. J. W. Marchetti. Radar on 50 centimeters, Jan. *98.....Feb. *98
Zelle, Joseph. Instantaneous program switching .....Feb. *142
Zworykin, V. K. & L. E. Flory. Reading aid for the blind.....Aug. *84

* Illustrated



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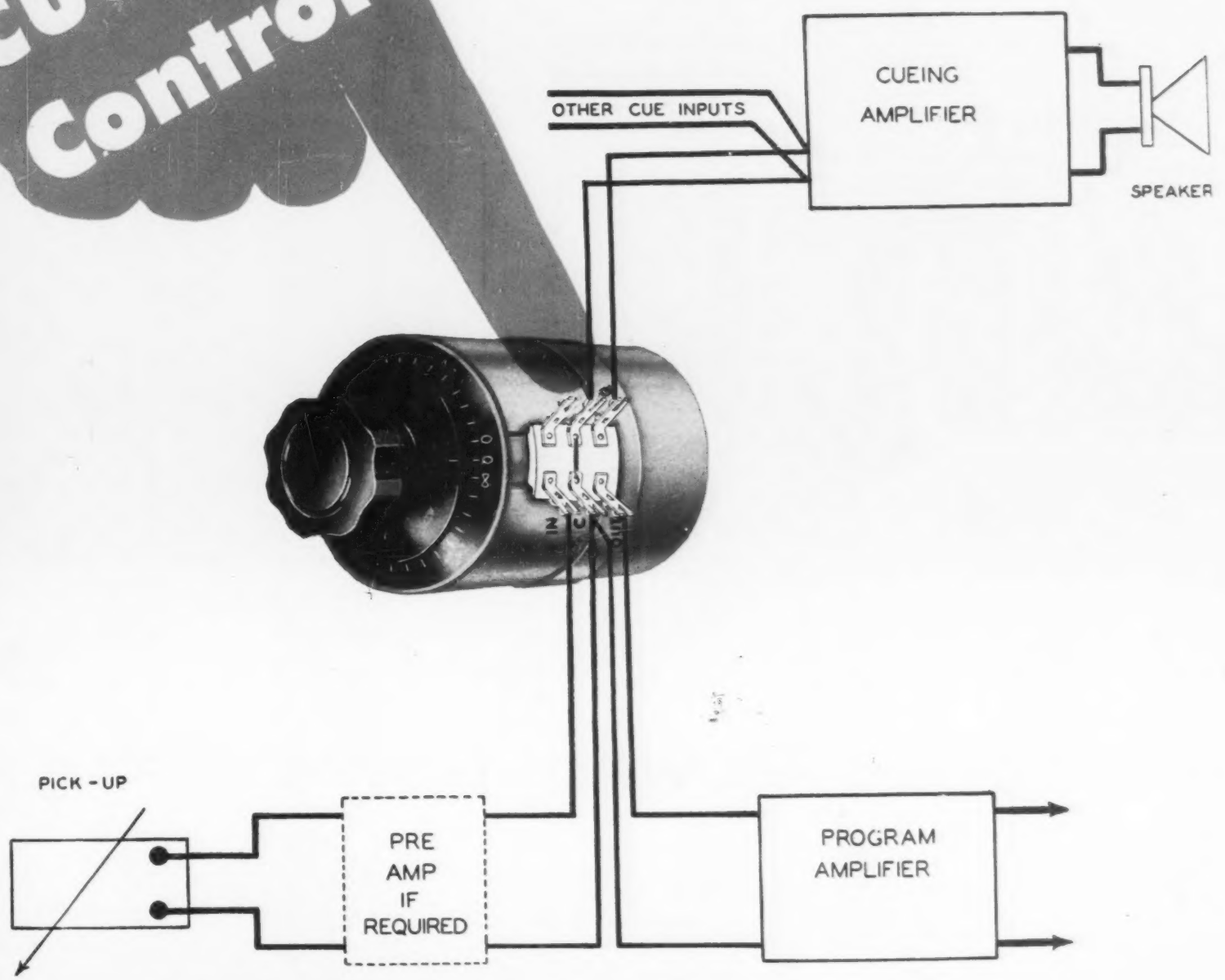

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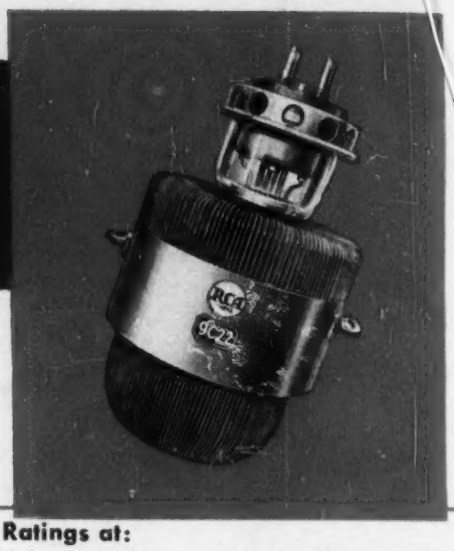

QUICK-REFERENCE POWER-FREQUENCY TABLE

Type No.	Class	Maximum Input Power (Watts) CCS Unmodulated Class C Ratings at:											
		1.6 Mc.	7.5 Mc.	15 Mc.	25 Mc.	50 Mc.	75 Mc.	110 Mc.	150 Mc.	200 Mc.	250 Mc.	300 Mc.	600 Mc.
9C21	Triode	150000	150000	150000	105000								
9C22	Triode	100000	91000	80000	70000								
9C25	Triode	40000	40000	40000	40000	25000	25000	25000					
9C27	Triode	40000	40000	40000	40000	25000	25000	25000					
892	Triode	30000	22500	17000									
892R	Triode	18000	13500	10500									
889-A	Triode	16000	16000	16000	16000	16000	14000	11000	8000				
889R-A	Triode	16000	16000	16000	16000	13500	10000						
8D21*	Tetrode	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	
7C24	Triode	5000	5000	5000	5000	5000	5000	5000					
833-A	Triode	1800	1800	1800	1750	1500	1200						
6C24	Triode	1500	1500	1500	1500	1500	1500	1500	1500				
4-125A/4D21	Tetrode	500	500	500	500	500	500	500	500	425	335		
8000	Triode	500	500	500	500	400	300						
813	Beam Power	360	360	360	360	300							
8005	Triode	240	240	240	240	195							
828	Pentode	200	200	200	200	160	130						
811	Triode	155	155	155	155	155	125						
812	Triode	155	155	155	155	155	125						
826	Triode	125	125	125	125	125	125	125	125	125	125	100	
829-B*	Beam Power	120	120	120	120	120	120	120	120	120	105		
8025-A	Triode	75	75	75	75	75	75	75	75	75	75	75	75
815*	Beam Power	60	60	60	60	60	60	60	55	40			
807	Beam Power	60	60	60	60	60	50	40					
2E24†	Beam Power	40	40	40	40	40	40	40	33				
832-A*	Beam Power	36	36	36	36	36	36	36	36	36	32		
2E26	Beam Power	30	30	30	30	30	30	30	25				
802	Pentode	25	25	25	25	20	16						

*Twin type—input values per tube for push-pull operation.

†Recommended only for highly intermittent applications. Input values are ICAS ratings.

The accompanying table of ratings vs. operating frequency provides the design engineer with a simple and rapid means of choosing the most suitable RCA tubes to meet the power and frequency requirements of equipment in the design stages.

Technical Literature

Detailed data on all the types listed are provided in the RCA HB-3 TUBE HANDBOOK. Technical bulletins covering tube types in which you are interested will be sent on request.

Application Engineering Service

RCA tube application engineers will be pleased to cooperate with you in adapting these or any other RCA tube types to your equipment designs. Just write RCA, Commercial Engineering, Section D-6L, Harrison, N. J.

RCA Laboratories, Princeton, N. J.
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TUBE DEPARTMENT

RADIO CORPORATION of AMERICA

HARRISON, N. J.

ELECTRONICS

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Index to electronics Volume XX

January to December issues, inclusive, 1947

Cumulative Index (April 1930—December 1944) available at 75 cents

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Acoustics:

Acoustic locating system, E. A. Walker and F. M. Kendig.....p 124, Feb
Automatic audio phase reverser, A. H. Smith .....p 156, Nov
Dynamic noise suppressor, H. H. Scott .....p 96, Dec
Experimental audio output tetrode, W. S. Brian.....p 121, Aug
Experiments in listening, N. D. Webster and F. C. McPeak.....p 90, Apr
Frequency range preference for speech and music, H. F. Olson..p 80, Aug
High-fidelity reproduction of music, E. Toth .....p 108, June
Noise reduction circuits, audio, H. F. Olson .....p 118, Dec
Reverberation time nomographs, R. C. Coile .....p 142, Apr
Wavelengths of sound, B. M. Henvis p 134, Mar

Aeronautics:

Aircraft antenna pattern plotter, O. H. Schmitt and W. P. Payser.p 88, May
Automatic controls for pilotless ocean flight, JM.....p 88, Dec
Cavity aircraft antenna, H. Kees and F. Gehres .....p 78, Jan
International plan for air navigation, D. H. Pain.....p 80, Feb
Shunt-fed wing antenna (TAW)..p 154, July
Status of vhf facilities for aviation, P. Caporale .....p 90 Oct
Two-way teletype in air (TAW)..p 168, Apr

Amplifiers:

Applications of magnetic amplifiers, W. E. Greene.....p 124, Sept
Automatic gain control and limiting amplifier, W. M. Jurek and J. H. Guenther.....p 94, Sept
Carrier-type amplifier for electric gages, H. C. Roberts.....p 92, May
Constant-gain knock pickup amplifier, R. P. Krebs and T. Dallas..p 87, Jan
D-c amplifier for low-level signals, C. B. Aiken and W. C. Welz....p 124, Oct
Electromechanical d-c amplifier, C. G. Roper and J. F. Engelberger.p 117, Nov
Four-tetrode f-m power amplifier (TAW) .....p 132 Aug
General purpose portable amplifier, C. R. Smitley.....p 150, Oct
High-gain d-c amplifier, W. G. Shepard .....p 138, Oct
Magnetron as d-c amplifier (TEA) p 182, Nov
Remote amplifier and program meter, D. V. R. Drenner.....p 140, Dec
Self-switching r-f amplifier, H. W. Wagner and J. F. Herrick....p. 128, June
Stabilized d-c amplifier with high sensitivity, H. A. Anker.....p 138, June
Wide-band i-f amplifiers above 100 mc, M. T. Lebenbaum.....p 138, Apr

Antennas:

Aircraft antenna pattern plotter, O. H. Schmitt and W. P. Payser...p 88, May
Antenna, 2,500-foot vertical (TAW) p 188, May
Cavity aircraft antenna, H. Kees and P. Gehres.....p 78, Jan
Effect of feed on pattern of wire antennas, D. C. Cleckner.....p 103, Aug
Helical beam antenna, J. D. Kraus p 109, Apr
Microwave antenna beam evaluator, H. LeCaine and M. Katchky..p 116, Aug.
Phase monitor for broadcast arrays, B. C. O'Brien and F. L. Sherwood p 109, Dec
Radio frequency vs. utility, E. A. Laport .....p 106, June-15
Slotted-cylinder antenna, E. C. Jordan and W. E. Miller.....p 90, Feb
Square loop f-m antenna (TAW).p 166, Mar
Shunt-fed wing antenna (TAW)..p 154, July
Television antenna problem, the, Staff .....p 88, Apr
Television antennas for apartments, D. G. F.....p 96, May
Triplex antenna for television and f-m, L. J. Wolf.....p 88, July

Broadcasting:

Broadcast carrier system (TAW).p 174, Apr
Carrier failure alarm, R. E. Thornton .....p 142, Jan
Emergency broadcast pickup techniques, G. Riley.....p 108, May
F-m chain broadcasting, A. A. McK. p 94, Nov
KSBR's 50-kw f-m transmitter, R. L. Norton, B. O. Ballou, and R. H. Chamberlin .....p 80, Oct
Phase monitor for broadcast arrays, B. C. O'Brien and F. L. Sherwood p 109, Dec
Railway entertainment system, K. L. Klippel and E. A. Dahl.....p 118, May
Recording sky-wave signals from broadcast stations, W. B. Smith p 112, Nov
Remote amplifier and program meter, D. V. R. Drenner.....p 140, Dec

Circuits in general:

Afc at 10 centimeters (TAW)....p 148, Apr
Background noise suppressor (TEA) p 142, June
Cathode-follower impedance nomograph, M. B. Kline.....p 130, July
Cathode-follower nomograph for pentodes, M. B. Kline.....p 136, June
Cathode-follower nomograph for triodes, M. B. Kline.....p 136, May
Classroom demonstration of cathode follower (TEA) .....p 188, Feb
Clipping and clamping circuits, N. W. Mather .....p 111, July
Db gain-loss calculator, L. A. Lohr p 134, Feb
Diode contact potential for negative bias, H. T. Sterling.....p 164, Oct
Electronic ignition system (IC)..p 184, Feb
Experimental ignition systems (TEA) .....p 180, July
Graphical Fourier analysis, T. C. Blow .....p 194, Dec
Graphical solutions for cathode followers, H. L. Krauss.....p 116, Jan
H-f automobile ignition (TEA)..p 136, Oct
Hum-reducing circuit, A. H. Smith p 130, Jan
Inductive coupling, efficiency of, A. C. Hudson.....p 138, Dec
Method of plotting tracking error, E. B. Menzies.....p 128, Jan
Negative impedance (TEA).....p 198, Mar
Noise suppression circuit (TEA).p 202, Mar
Nonlinear limiter, E. R. Brill...p 198, May
R-C bandpass filter design, J. L. Bowers .....p 131, Apr
Self balancing phase inverter (TEA) .....p 212, Mar
Shielding filters for insertion loss measurements, G. J. Wheeler..p 198, Mar
Simplified microwave afc, F. A. Jenks, Part I, p 120, Nov; Part II p 132, Dec
Square-wave response, A. J. Baracket .....p 130, Aug
Steepness of pulse fronts, M. D. Rubin .....p 136, Sept
Surge protection of pilot and heater circuits, R. P. Glover.....p 134, Aug
Three-band variable equalizer, L. D. Grignon .....p 112, Jan
Tracking the permeability-tuned circuits, A. W. Simon.....p 142, Nov
Variable time constant, T. Petrides p 138, Oct

Communications:

Carrier system f-m short-range, E. H. B. Bartelink and E. Daskam.. p 112, Dec
Citizens radio project, ELECTRONICS sponsors, Staff.....p 80, Nov
Citizens radio service, transmitter for the, W. C. Hollis.....p 84, Nov
Code reception with avc and S meter (TAW) .....p 132, July
Experimental uhf equipment (TEA) p 204, Mar
First factory f-m radiophone (IC).. p 188, Mar
French coax cable laid (TAW)...p 178, Dec
French microwave telephone circuit (TEA) .....p 138, Jan
Infrasonic switching, J. R. Cooney, J. H. Holmes, A. B. Shone, I. Gelles, and A. Montani.....p 174, Aug
Microwave communication system (TAW) .....p 138, Mar
Photoelectric transmitting typewriter, G. Bush.....p 96, Apr
Portable inductive radiophone, W. R. Triem .....p 93, Dec
Radio dispatching of taxicabs, A. A. McK. .....p 97, Mar
Two-way railroad pack set (TAW) p 190, May
Two-way taxicab radio circuits (TAW) .....p 146, Apr
Vhf link for press photos, A. A. McK. .....p 100, Aug

Components:

Capacitors, overvoltage testing of, R. J. Hopkins .....p 105, June
Coaxial junctions, tapered, S. Hershfield .....p 146, Dec
Compact electromechanical filter, R. Adler .....p 100, Apr
Guillotine tuner for f-m (TAW)..p 136, Feb
Low-loss plastic insulation materials, J. H. Parliman.....p 116, June-15
Mercury delay lines, design of, T. K. Sharpless .....p 134, Nov
Mercury memory tanks in new EDVAC computer (TAW).....p 168, May
Metallized capacitor data (TAW).. p 174, Mar
Metallized capacitor tests, P. Godley and J. C. Balsbaugh.....p 112, Apr
Miniature capacitors (TEA).....p 194, May
Operating batteries at low temperatures (TEA) .....p 174, Aug
Printed vitreous enamel components, C. I. Bradford, B. L. Waller, and S. A. McNeight.....p 106, Dec
Silicon and germanium rectifiers.. p 146, June-15
Stabilizing electrical and mechanical characteristics of circuits (TEA) p 136, July
Waveguide data, L. E. Sherbin..p 122, Jan

Counters and timers:

Cathode-coupled half-shot multivibrator, R. K. F. Scal.....p 150, Sept
Electronic switch for the production of pulses, C. R. Smitley and R. E. Graber .....p 128, Apr
Fluorescent lamp delay timer (IC) p 184, Mar
Interval timer, E. L. Deeter and W. K. Dau .....p 86, July